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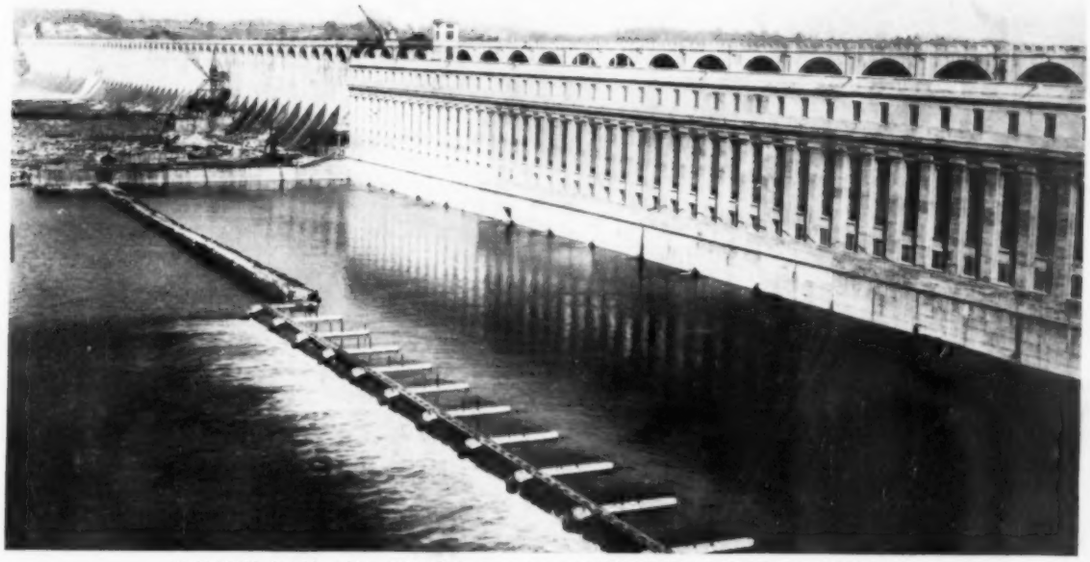

WILSON DAM AND POWER PLANT, TENNESSEE RIVER, ALABAMA.

SUPER-POWER FROM A MILITARY STANDPOINT
Gen. Guy E. Tripp

WILSON DAM AND NATIONAL DEFENSE
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RELATION OF UTILITIES TO PREPAREDNESS
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HYDRO-ELECTRIC DEVELOPMENT UNDER THE FEDERAL WATER POWER ACT
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THE INDUSTRIAL ENGINEER IN NATIONAL DEFENSE
Maj. R. R. Nix, Ord. Dept., U. S. A.

THE ELECTRIC POWER SURVEY
Maj. G. R. Young, Corps of Engineers, U. S. A.

TRAINING THE STAFF FOR OPERATING MODERN POWER PLANTS
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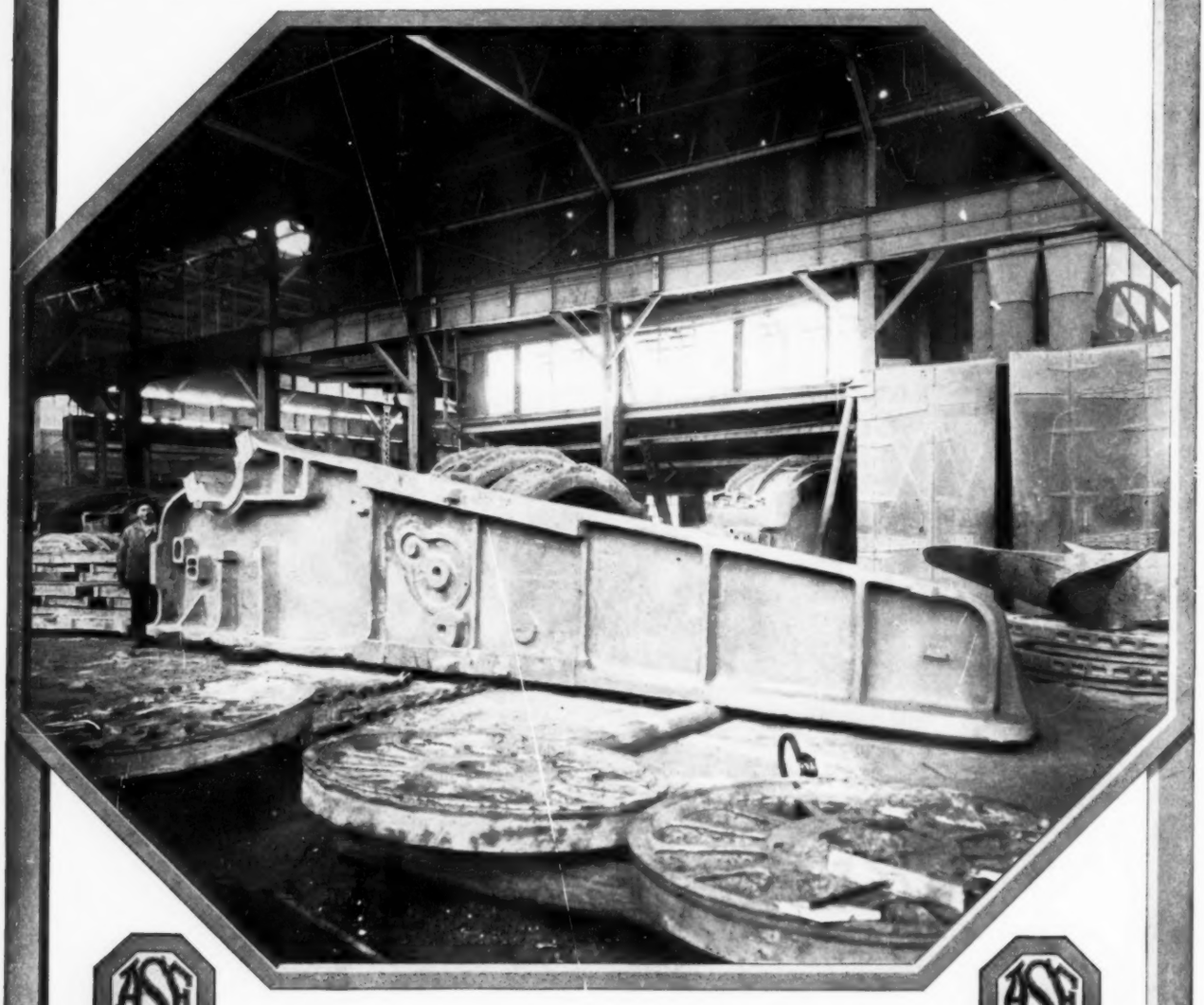
THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

AMERICAN STEEL FOUNDRIES



STEEL CASTINGS
OF EVERY DESCRIPTION
FOR
ARMY AND NAVY REQUIREMENTS

NEW YORK CHICAGO ST. LOUIS

ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

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Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

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¶ The time has passed when military preparedness can be considered merely a question of trained man-power. The development of the methods of modern warfare must be supplemented with a knowledge of the methods of production of modern implements of war. Experience has shown that men can be mobilized and reasonably trained in from three to six months if the necessary ordnance is available. Industry today requires for mobilization and mass production of war material a period of from nine to eighteen months. The mobilization of the munitions industries is the Ordnance problem.

¶ America has an abundance of physically fit men of military age. It has also the Regular Army, the National Guard, the Organized Reserves, summer training camps, national rifle matches, all of which are effective agencies for converting this raw personnel into trained man-power. America needs an organization which will create a potentiality for the manufacture of war materials in order that its preparedness may be completely rounded.

¶ The industries of America know perfectly well how to house, to feed, to clothe, to transport men called to the colors. The civilian professions of medicine, surgery, dentistry, law and banking similarly develop great reservoirs of readily available personnel for preserving and restoring the health of an expanded army, for administering its judicial system, and for paying it.

¶ But, a man, even a man of military training—well fed, well housed, well clothed, well paid, is not a soldier until he receives the tools of his trade—ORDNANCE.

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Antiaircraft

Super-Power From a Military Standpoint

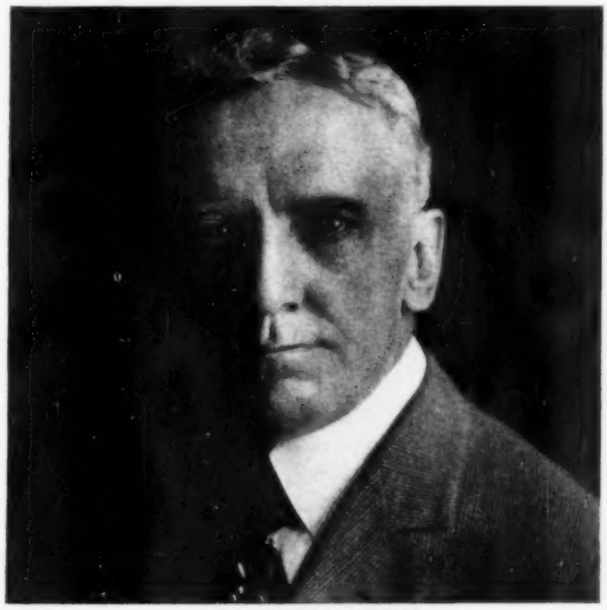
By

Gen. Guy E. Tripp

MILITARY considerations have had little influence on the course of industrial development in America. This is, broadly speaking, something for which we have cause to be thankful. Militarism is born of fear and feeds on high taxes; and in being free from it, we are more fortunate than many other nations.

It must be admitted, however, that with this gain, there is also some loss. Because scant attention is paid to military factors in this country, our national defenses are in many respects weak, and the War Department is continuously at work planning to counterbalance deficiencies that are constantly appearing in our military situation.

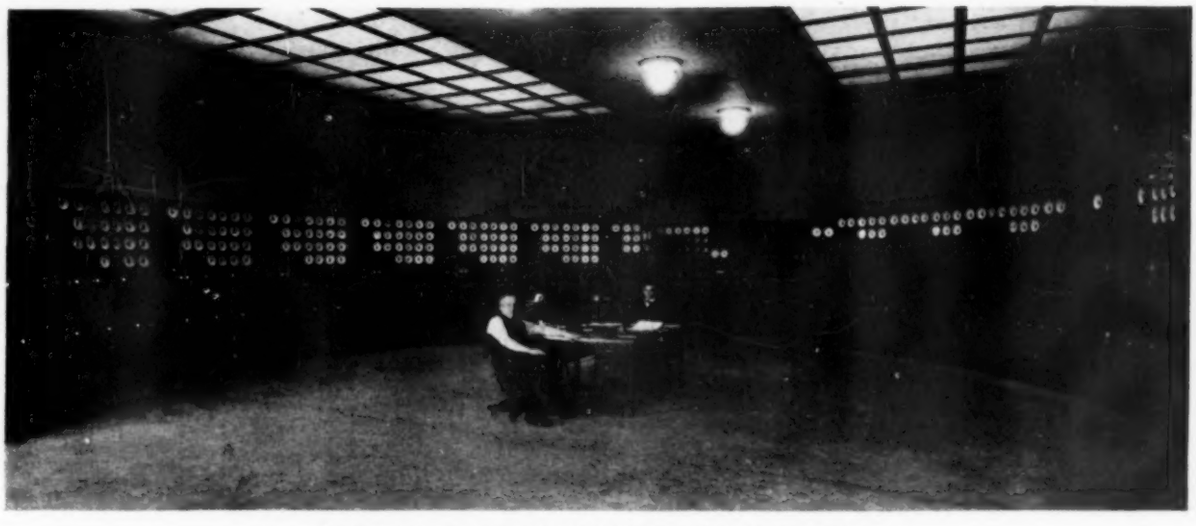
It is, therefore, highly gratifying when any of our major industries develops naturally along lines that are thoroughly satisfactory from a military standpoint—and this, it is believed, is the case with electric power.



GEN. GUY E. TRIPP
Vice-President, Army Ordnance Association, Chairman, Westinghouse Electric and Manufacturing Co.

As Colonel Charles Keller has pointed out, electric power is one of the major factors in the war-making strength of a nation, being coordinate with man-power, fuel, transportation, and industrial development. It is likewise a comparatively new factor, appearing for the first time in the World War and being then utilized extensively only by the United States and Germany.

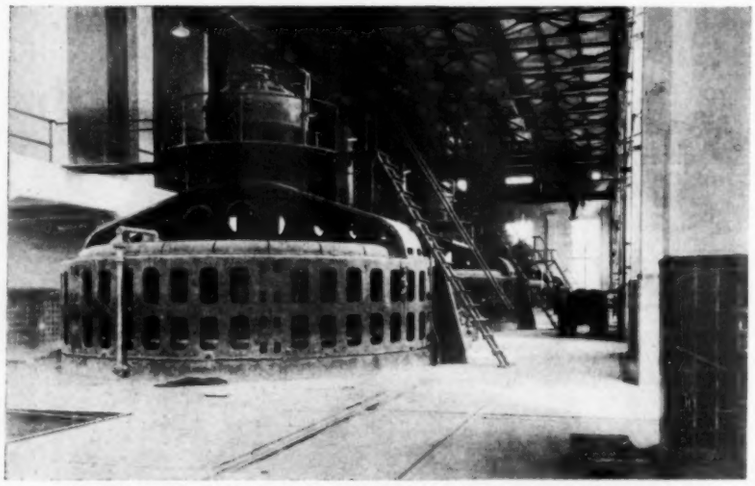
During the few years which have passed since the war, the American power industry has made vast progress, and is undoubtedly constantly increasing our potential military power. While no layman can hope to treat a technical matter of this sort adequately, a discussion of the military value of modern electric developments may prove of



Control Room, Main Plant, the Niagara Falls Power Co.

This panel is the generator control for over 400,000 horse-power. Here the electrical power produced by Niagara's tumbling torrents starts on its journey through western New York to lighten labor for more than two million people.

interest and possibly stimulate the preparation of an authorative treatise on the subject which would be given due consideration when broad plans for the extension of electric service are being formulated.



Interior, Mountain Island (North Carolina) Power Plant of the Southern Power Co.

It is not necessary to describe these developments in detail as they are well-known to every engineer. Their chief characteristic is, of course, the interconnection and integration of formerly independent electric systems into so-called "super-power" systems—a process which promises to continue until a few very large systems serve the greater part of the inhabited area of the United States.

Two important ends are being attained by this process. In the first place, it is providing us with an ever-increasing amount of power from the most economical sources (the military value of which is self-evident); and secondly, it is distributing this power over ever-increasing areas, and to an ever-increasing number of people.

Where electric power systems are small and isolated, electric service is confined almost exclusively to congested centers. Super-power systems, however, are making power available in inter-urban districts where it has heretofore been unobtainable; and this is making possible the decentralization of our industries and population.

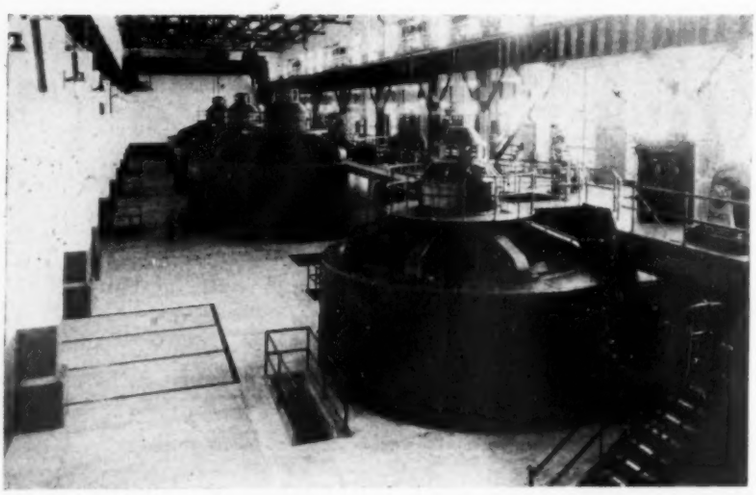
Until now, the tendency has been for our cities to grow at the expense of our rural districts, but when power can be obtained almost anywhere, the next generation or so may see a countryside of garden communities with many relatively small industrial plants of all kinds scattered everywhere.

One of the first and most important effects of decentralization would be a marked improvement in the position of the American farmer. Not only would living conditions in the country become nearly, if not quite, as satisfactory as those in the city, but opportunities for earning a livelihood would be greatly multiplied. The farmer would be able to spend the idle periods of his highly seasonal occupation in industrial work, and those members of his family who have no taste for farm labor would be able to find congenial employment without going to the city. The family as a whole would enjoy greater prosperity and the present tendency to break up the family life would be decreased. With life in the country on a better basis, would come a corresponding increase in our political stability, and consequently a proportionate growth of our potential military strength.

Moreover, communities which are absolutely dependent upon a single occupation, such as wheat-growing or one-commodity manufacturing, are at the mercy of the economic vicissitudes of their products. Political unrest and radicalism inevitably follow low prices in specialized communities. But so far as industries of various kinds can be scattered throughout the country, the business factors will become diversified, and depression in one line will often be counterbalanced by prosperity in others. In other words, decentralization of industries will tend to prevent the formation of geographical blocs, which are almost always detrimental to national unity.

Especially satisfactory from a military standpoint will be the extensive growth of industries within the bounds of our great natural defenses—the Allegheny Mountains on the east, and the Rockies on the west—a growth made possible by a super-power development. One of our great potential weaknesses in case of war is that too many of our munition factories are now located in the Atlantic Coast region where they lie open to attack. As the number and variety of our industries in the Mississippi Valley and the middle-west increase, our natural defense situation will be correspondingly improved.

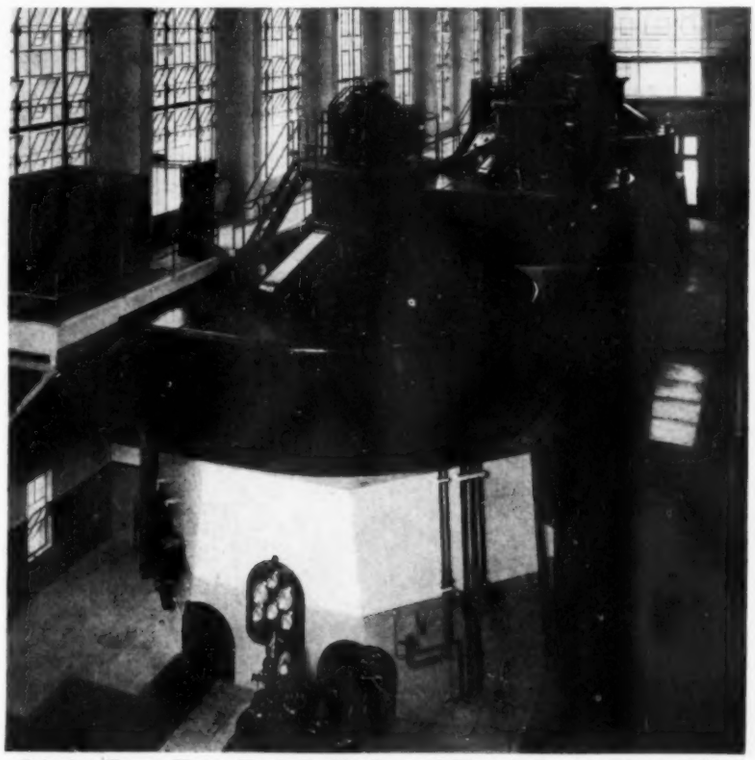
There is also a decided military gain in the fact that as the use of electric power in industries increases, the greater the production per worker becomes. This gain is secured through the use of more efficient, and especially, automatic machinery. As electric development proceeds, therefore, the number of men needed to produce a given quantity of munitions is being constantly decreased, thus increasing our potential man-power for active service.



Interior of the Main Plant of the Niagara Falls Power Co.

When the industries of a given district are being supplied with power from a large number of small and independent units, it is very difficult, in war emergencies, to shift the power from non-essential to essential industries. This, in fact, was one of the problems of the last war. Where, however, all the industries in the district are served from the same system, it is a simple matter to supply power to industries in the order of their military value.

In particular, a thing that proved to be practically impossible during the last war can be easily accomplished under an extensive super-power development, namely, the concentration of large blocks of power at single points for the production of such war material as poison gas, powder, nitrates, and ferro-alloys. The developments at Muscle Shoals and Old Hickory represent heroic efforts on the part of the War Department to solve this problem, but neither of these undertakings was completed in time to be of military value.



Interior, Power House No. 3, Pacific Gas and Electric Co., Pit River, Calif.

Super-power development also makes possible considerable improvement in our transportation facilities, a military asset of the highest order. It will facilitate electrification of our main railroad lines, which, if carried out on a large scale, will greatly increase our traffic capacity as a whole, and will eliminate much haulage of coal. At the same time, the decentralization of population and industries will inevitably result in an increase in our net-work of good highways, which will expedite the use of motor vehicles, thereby improving our secondary transportation.

If, due to excessive war demands, a given super-power system should be over-loaded, the deficiency can be made good by installing additional generating apparatus at any suitable point on the system. A considerable amount of electrical generating apparatus is always in a more or less finished state in the shops of the various electrical manufacturing companies (during the last war, about a million kilowatts in sizes of 10,000 k. w. and larger, were in this condition) and where extensive super-power development obtains, this apparatus would, in the natural course of events, be mainly in large standardized units, which, being applicable almost anywhere, could be promptly commandeered in case of war and used to take care of the most pressing needs. This simple remedy is not so effective where electric systems are small and isolated.

Not the least important feature of super-power development is the fact that it permits full utilization of our water-power resources. Under conditions that obtained at the time of the last war, most of our waterpowers were undeveloped, because some of them were too far away from the nearest point of consumption and others were too large for local needs. With super-power, however, the development of most of the water-powers in the United States becomes feasible in peace-time. As things are today, even the millions of horsepower of the St. Lawrence River could, if available, be promptly and profitably absorbed by the great electric systems of New England and the middle-Atlantic states.

When considered from the economic standpoint, the value of a given water-power compared to a corresponding steam plant depends solely on the cost of the power generated. In many cases, steam-power will be cheaper and therefore preferred. From a military standpoint, however, water-power is vastly superior to steam power.

Steam plants are dependent upon fuel supplies; and this means that they are also dependent upon those who supply the fuel. It so happened during the last war that most of the coal miners were in sympathy with the Allies and made commendable efforts to increase production during the emergency. It is quite conceivable, however, that in another war, due to our mixed population, a portion of the coal miners, for example, might be sympathetic with the enemy in which case difficulties in maintaining fuel supplies might result. Water-power being independent of fuel, is not subject to this danger. It is also more easily protected than a steam plant with its attendant coal mines, and it can be operated by smaller forces, the greater portion of which need not be highly skilled. A water-power plant of large capacity could, in fact, be operated in an emergency by a number of women and farm boys under the direction of a few competent engineers.

The capital invested in water-power development (which can be roughly figured at $250 per kilowatt as compared with $100 per kilowatt for a corresponding steam-power plant), represents labor stored during peace-times and available for use to the utmost advantage in war. It was estimated during the World War that a water-power plant could be operated with one-twentieth the man-power needed for a corresponding steam plant with its coal mines, and

it is believed that under modern conditions, this proportion is still greater.

Next to water-power, steam plants located on coal mines have the greatest military value because no railroads are required to haul the coal, thus simplifying the plants' physical requirements and conserving man-power and transportation. Next in order come steam plants located on navigable inland waterways, and finally plants wholly dependent upon railroads and tidewater for their fuel supply.

Another advantage of super-power which is becoming increasingly important, is its ability to use "by-product" power. Studies of various industries indicate that certain of them can at small expense develop comparatively large amounts of power as a by-product of some of their processes. Such industries can themselves rarely consume all the power they can generate, nor can they dispose of large quantities of it to small isolated electric systems. But where a super-power system exists in the vicinity, by-product power in any amount can be turned directly into the system, thus benefiting the industry, the power system, and the consumer. Power supplies of this kind have about the same military value as water-power, since in most cases, the industries supplying them would be operated at full capacity in the event of war.

These few facts could be considerably augmented, but they are, it is believed, sufficient to show that the more extensive the growth of our electrical power industry along present lines, the greater will be the military strength of our nation.

Cincinnati Post, Army Ordnance Association, Inaugurates Officers

THE annual meeting and inauguration of officers of the Cincinnati Post, Army Ordnance Association, was held at the Chamber of Commerce, Cincinnati, February 17, 1926. As a result of an election, balloting under which closed on January 15th, the following officers of the Post were inaugurated at the meeting: President, E. A. Muller; Vice President, J. Wallace Carrel; Directors for one year: Fred W. Hinkle, E. B. Danson, Capt. E. H. Boeckh, Ord. Res., and W. I. Ohmer; National Director, Casper H. Rowe; Directors for two years: W. G. Wall, William Groene, Casper H. Rowe, and Capt. Robert S. Barr, Ord. Dept., U. S. A.

The present Secretary, Captain Boeckh, and Treasurer, Captain Barr, will continue to hold office in their respective capacities.

The meeting was a most successful one. At the business gathering at 6:30, where the officers and directors were inaugurated, plans for future meetings and activities of the Post were discussed. After this conference, dinner was partaken jointly with the Officers Association of Cincinnati. Addresses were delivered by Lt. Col. H. W. T. Collins, Ord. Res., Chief of the Artillery Division, Cincinnati Ordnance District; Hon. W. Irving Glover, Second Assistant Postmaster General; and Maj. Gen. Robert L. Howze, U. S. A., Commanding General, Fifth Corps Area.

Colonel Collins spoke on industrial preparedness and its particular application to the Cincinnati Ordnance District. He gave a full exposition of the necessity of procurement planning in peace time and recited some of the difficulties in manufacturing ordnance with which the industries of America should be familiar. He also described the war planning system as in operation by the Ordnance Department, emphasizing the difficult requirements which must be met to assure an adequate supply of ordnance in war.

The Second Assistant Postmaster General addressed the gathering on the development of the Airplane Mail Service and told of the accomplishments and plans of the Post Office Department for furthering this important service.

General Howze, while discussing preparedness measures generally, devoted a great deal of his address to the Army Air Service, comparing it with the air services of other nations and answering many of the criticisms that have been recently leveled against it. General Howze also warned all present against propaganda of the pacifists, assuring the audience that there was no cause for alarm so long as such organizations as the Army Ordnance Association, the Reserve Officers' Training Corps, the National Guard and other patriotic agencies carried on the important work they now have under way. General Howze closed with an appeal that the Reserve Officers' Training Corps be maintained in the colleges of our country, and that the histories in our public schools continue to teach patriotic subjects and to stress the important campaigns of our military and naval heroes.

The meeting was a most enthusiastic one, 149 persons being in attendance.

Wilson Dam and National Defense

By

Maj. M. C. Tyler, Corps of Engineers, U. S. A.

NOT so long ago, just before the World War, National Defense to most of us meant the training of officers and troops for field service. Military men paid little or no attention to the problems of supply, munitions and transportation except in connection with the operation of combat units. At the Command and General Staff School, Fort Leavenworth, the relation of industry to war was touched upon, but only in passing.

The technical officer, working on experiments in the bacteriological laboratory, in the arsneal, or engaged on public works, felt that his work, if good, might add as much to our military strength as that of the officer on duty with troops, but he knew better than to express such unmilitary ideas. Through force of circumstances, our conception of national defense has been broadened, and we all now know that a maximum effort can be successful only when it is made by good troops in the field backed up by a sufficient and well managed industry and transportation at home. Consequently, the Army is giving serious study to our resources in raw materials, our industries, our electric power systems and our transportation facilities, and is keeping plans for their best use in time of war up to date.

Now that we have such a broad view of national defense, perhaps one may venture the thought that we do no yet fully realize the military value and military significance of our great public works, nor fully appreciate the far-seeing wisdom of the War Department in urging upon Congress their construction in time of peace.

Can we even approximately estimate what the Soo Locks and the improved channels of the Great Lakes have added to our military stregnth? The great steel industry in the Pittsburgh district was made possible by their construction.

Through those locks and channels, between 1914 and 1919, passed the immense tonnage of steel (in the shape of iron ore) and grain used by the Allies and ourselves in the war. Moreover, the Pittsburgh district, built up by Great Lakes navigation, from its dense population furnished a large quota of troops. Weitzel[1] and Poe[2], who did the pioneer work at the Soo, served with distinction at the front in the Sixties, but I wonder if their labors in improving navigation were not of as great military value in 1917-18 as had been their combatant services in 1864-65.

Second in importance only to Lake navigation with respect to the Pittsburgh district is that other War Department project, the canalized Monongahela River, which carries annually over 20,000,000 tons of freight vitally essential to industry both in peace and war.

Likewise, it would be interesting to estimate what the Ambrose Channel leading into New York Harbor added to our war effort. Only through its excavation in peace time was it made possible to move trops and supplies in heavy draft vessels from the Port of New York. Without it the *Leviathan* would never have been built to fall into our hands for use as a transport. Surely the work of Marshall[3] on that waterway had as great an effect in the war as that of many officers who commanded troops.

And so with many other projects which the War Department has carried through to completion in the palmy days of peace. The deep draft channels at such ports as Norfolk, New Orleans, Galveston, Los Angeles and Portland (Oregon) are helping to build up our commerce and industry, and hence our military strength; but any one of them, in an emergency, may become a most important factor in military operations.

Any great public work which enables more Americans to live according to the high American standards adds just that much to our defensive strength in intelligent and physically fit man power and ability to produce war necessities. Any public work which increases our transportation facilities adds to our ability to use our strength in defense of our rights. And a project which does both, provides better transportation or a new transportation route and supports a large additional population in useful industry in peace and war, surely is a material addition to the national defense.

Wilson Dam (Dam No. 2), Tennessee River, is such an undertaking. It is another of those important "civil" works, built by the War Department which will be of great value to industry and commerce in time of peace and inestimable military worth in time of war. It has two missions, viz., the generation of electric power and the improvement of navigation.

The dam is located at the foot of the Muscle Shoals. It is about one hundred and twenty-five miles south of Nashville, about one hundred miles north-northwest of Birmingham, and about one hundred and fifty miles east of Memphis. It concentrates at one point the ninety-five feet of fall which, in the original condition of the river, occurred in fifteen miles. The lake behind the dam has an area of 14,500 acres, which affords no storage. The flow of the Tennessee River at the site varies between

1G. Weitzel, Major General, U. S. V., Comdg. XVIII Corps, '64-65.

2O. M. Poe, Colonel, Chief Engineer to General W. T. Sherman, '64-65.

3W. L. Marshall, Chief of Engineers, U. S. A., 1908-10.

about 6,000 cubic feet per second in the driest season to nearly 500,000 cubic feet per second in the extreme flood of record. The lake is maintained at a constant level, 501 feet above sea level. The crest of the dam spillway is 18 feet below the lake level, fifty-eight spillway gates 38 feet long by 18 feet high being provided to regulate the lake level and to pass floods. To provide bearings for these gates and platforms for their operating machinery and to provide also a highway across the Tennessee River, an arch bridge extends from bank to bank over the dam and forebay structures. The powerhouse forebay is in line with and forms a part of the dam.

Down-stream View of Wilson Dam showing 14 Gates open.

Wheel pits for eighteen main units are provided in the powerhouse, or a total possible ultimate installation of 610,000 horsepower. Eight units are installed, four of 30,000 horsepower and four of 35,000 horsepower, or a total of 260,000 horsepower. The first four are I. P. Morris turbines and Westinghouse generators; the second four Newport News Shipbuilding and Dry Dock Company turbines and General Electric Company generators. The Government does not plan to install more than the eight units at the present time.

The locks are on the north bank of the river, the powerhouse being on the south side, and are two in flight, each having available dimensions 300 feet by 60 feet. All masonry structures are of concrete and massive in design. The total of concrete masonry amounts to about 1,300,000 cubic yards. The total cost of the eight unit installation, in round numbers, will be $46,000,000, which does not include step-up transformer station, for which no appropriation has been made. The navigation benefits are estimated as worth $9,000,000, leaving $37,000,000 as the investment for power purposes.

The Muscle Shoals section of the Tennessee River prior to the completion of the work under discussion never was capable of navigation during the low water season. The total fall of the river between Chattanooga and the mouth at Paducah, Kentucky, on the Ohio, is 343 feet. 105 feet of this total fall occur in the eighteen miles between Florence, Alabama, and the head of the Wilson Dam Lake. This section, by the construction of Wilson Dam and the lower approach thereto, consisting of a lock 300 feet by 60 feet, a low dam and a three mile lateral canal, now is afforded a 9-foot navigable depth in all seasons. The construction of other dams for power and navigation ultimately will give a 9-foot depth from Paducah to Chattanooga, and probably to Knoxville.

The availability of cheap power in the Tennessee Valley will cause a great increase in industry, and manufacturing plants will locate along the river. We may reasonably expect in the not far distant future to see a large tonnage moved to and from this section by water.

Those of us who had the misfortune to serve in supply departments at home during the last emergency remember vividly and with horror the congestion of rail transportation and the fear of railroad strikes. The War Department's great system of locks and dams on the Ohio River is nearing completion and within three or four years all year round 9-foot navigation will be possible from Pittsburgh to Cairo and New Orleans. The canalization of the Tennessee River by the construction of power and navigation dams will add another important waterway, connecting with the Ohio and serving a new industrial area. The immense military value of this extensive inland transportation system, connecting industrial centers with the great and efficient port of New Orleans and assuring rapid freight movements of war ne-

cesities to the seaboard free from the hazards of rail congestion and railroad strikes, is apparent.

Electric power was one of the limiting factors of the production of war essentials in the last emergency, and will be of ever greater importance in the future. There seems to be no end in sight to the demand for power. The chemical industry, metallurgy, transportation, textiles, saw mills, pulp and paper mills, mines and quarries, and the multitude of fabricating plants, all must have power.

General View of Wilson Dam and Power House, June 30, 1925.

Wherever power can be generated and distributed at reasonable cost, and raw materials can be secured and the finished products moved to market at reasonable transportation rates, industry will follow. It may be new industry or it may be old established industry moved from older sections which have become too congested. In either case, from a military point of view, a distinct gain is made. Both kinds of growth are now taking place in the Southeastern States, all based on the availability of electric power, raw materials and transportation.

The Southeastern States are served by an inter-connected power system which covers an area from the Virginia-North Carolina line at its northeastern edge down through central North Carolina, northern South Carolina, northern Georgia and northern and central Alabama to Montgomery and Birmingham, Alabama, at its southwestern edge, and extends northward to Knoxville and Nashville, Tennessee. Muscle Shoals is at the present extreme western end of the system. Extensions are in progress south to the Gulf and southwest into Mississippi. The interconnected system is made up of twenty-one operating companies. Power is interchanged between adjacent operating companies on a large scale, and has been relayed at times from one end of the system to the other, viz., from Sheffield, Alabama, to North Carolina. The increase in the demand for power in the area covered by the interconnected system is rapid, and particularly so in that part of the region which can be served from Muscle Shoals.

We can hardly overestimate the value to the national defense which is accruing from the creation of a great industrial development in these states. This growth, depending as it does on electric power and coming at a time when the transmission of power over long distances has been developed, will be different in character from the congested industry of the Northeastern States. We may reasonably expect the industrial growth to be widely spread out along the main transportation routes and new transportation lines which will be built in the future. With the milder climate and room for proper housing, better living conditions will obtain. Better citizens, physically and intellectually, will be the result. Rail transportation, with yards and terminals built where there is room, in accordance with modern practice, will be more efficient. In all this growth, Wilson Dam, through its output of electric power, will be an important factor.

Wilson Dam power station is a "run of river" plant. Since the lake behind it affords no storage and since the flow of the river varies between such wide limits, the maximum annual amount of power can be obtained from it only by connecting it to and operating it in conjunction with steam stations and water storage plants. Such plants already exist in the adjacent part of the interconnected system and additional ones or enlargements are being added each year. The Government owns a 70,500 k.v.a. steam plant at Muscle Shoals, built as part of Nitrate

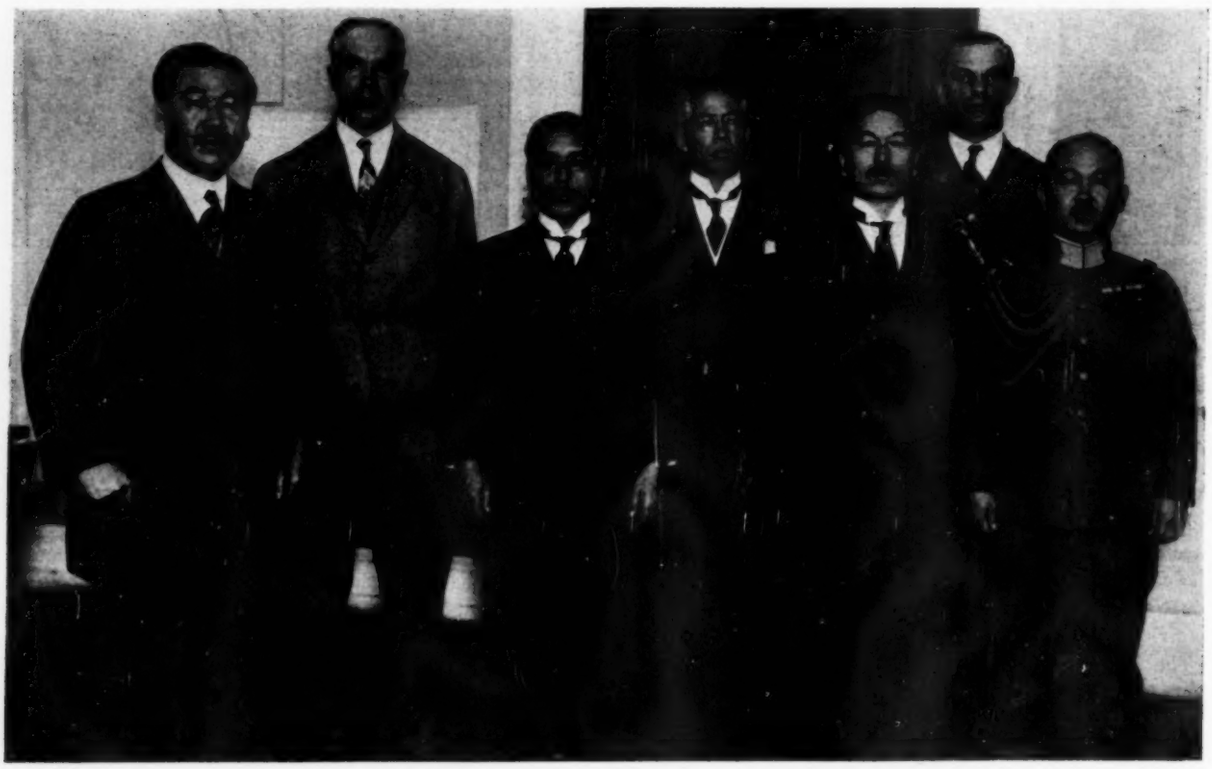
Plant No. 2. There is every reason to believe that if the Wilson Dam station and the Government's steam plant are operated on the inter-connected system, they will put into diversified industry in the adjacent territory 1,000,000,000 k. w. h. of energy per annum within five years.

To those familiar with the power situation in this territory, it seems obvious that the greatest amount of power, the lowest unit cost, and the best return to the Government on its invested capital can be secured by operation on the inter-connected system, and that the wide distribution of power in diversified industry thereby secured will result in greater benefits to this section of the South and to the country generally than can be obtained by any other possible use of the property. Others, however, hold a different opinion, and there is a strong demand that Wilson Dam and the Government's steam station be devoted to the operation of the War Department's war nitrate plants at Sheffield, Alabama, for the production of fertilizer in time of peace and ammonium nitrate for explosives in time of war. These two views, and the question of the merits of private operation versus Government operation, have caused all the political and technical discussion on "Muscle Shoals."

One fact, however, stands out clearly above the fog. The War Department has completed another great work, which since September 12, 1925, has been furnishing power to industry in the South. No matter what the immediate decision may be as to the disposition of the property, economic laws, in the end, will solve the problem and the ever increasing necessity for electric power will force its operation in the best interest of the public.

We may say, therefore, without fear of contradiction, that Wilson Dam has already entered upon its long tour of duty for the betterment of American industry, transportation and national defense.

General Sato, President, Japanese War College, Visits War Department



General N. Sato, Imperial Japanese Army, President of the Japanese War College, with a party of nine officers, visited the United States War Department, February 15, 1926. The distinguished visitors arrived in New York on February 12th, after an extended visit throughout Europe. Upon arrival in Washington, General Sato and his party paid their respects to officials and Army officers. After calling upon the Chief of Staff, they visited Bolling Field, Fort Meyer and the Army War College. The party left Washington February 17th for a visit to the United States Military Academy at West Point, and Niagara Falls, thence to journey across continent, embarking at San Francisco for Japan. Those in the picture are, left to right: Col. N. Morita, Japanese Military Attaché in Washington; Col. N. E. Margetts, General Staff, U. S. A.; General Sato; Col. O. Abata, Japanese War Office; Captain Maruyama, Assistant Military Attaché at London; Maj. R. C. Goetz, General Staff, U. S. A.; and Capt. K. Abe, Assistant Military Attaché at Washington.

The Relation of Utilities to Preparedness

By

Lt. Col. J. M. S. Waring, Ord. Res.

THE dependence of modern warfare upon the industries is, to put it more precisely, a dependence upon labor, raw materials, the apparatus for their conversion, and the utilities necessary to effect the conversion and to serve the community incident to the industry.

Our Government's recognition of the importance of modern industry to modern warfare, and its realization of the necessity for industrial preparedness in any plan for military preparedness has been evidenced since the World War by such manifestations as the provision by act of Congress for an Assistant Secretary of War in direct charge of industrial preparedness; the establishment of an Army Industrial College for officers; the enlistment of many industries who agree to participate in an emergency by furnishing supplies or materials as called for by the Army; and by a sincere and effective effort on the part of the Regular Army personnel to cooperate with and accomplish coordinated plans with the industries.

Railroad Receiving Yard, Explosives Plant "C," Nitro, W. Va.

No matter how complete or how restricted our preparedness plan may be, as determined by the will of our people or by economic considerations, its success must depend on the administrative policy governing our peace-time work of preparedness, and the efficiency of administration will depend upon the judgment used in determining the extent to which pre-war observations, plans and specifications should be carried. The greater the handicap of restricted funds and personnel, the greater the need of their careful and judicious use.

It is this thought, elementary though it be, which is responsible for this article, for utilities are a major consideration in most industrial plants from the standpoint of the time required for construction, construction costs, successful plant operation and operating costs; unless already available they cannot be furnished overnight; they call for forethought in the way of preliminary determinations and design, and the policies governing this phase of preparedness will weigh heavily in determining the speed, economy and therefore the measure of success of our general plans for preparedness.

The word "utilities" is at best a vague one, but for the purpose of this article it may be defined with sufficient precision as those services which are of the character ordinarily furnished to communities and their industries by public service corporations and municipalities.

Our interest lies in the demands for power, steam, transportation, water and sewerage, as fixed by the requirements of those departments interested in the procurement of war supplies, and in the supply of *utilities* as limited by the *facilities* available from such sources as the power companies, the railroad systems and highways, the water and sewerage systems of municipalities and the rivers and streams.

In the study of utilities we are faced with the fact that the various resources at our command cannot be utilized as we find them. Air must be heated, refrigerated, compressed, rarified, humidified or dried; water must be heated, cooled, filtered, chlorinated, softened; fuel must be converted into heat either for direct use or for further con-

version to steam, light or power. All or many of these treatments or conversions must be accomplished, according to the process or processes for which the industrial plant is designed. Furthermore, it is not alone sufficient to originate these services either by manufacture or purchase, for when this is accomplished they must be distributed to the places where they are to be used. Even then provision must be made for conserving or disposing of the waste resulting from many of the utilities.

Sedimentation Basin, Nitro, W. Va.

Thus, even when a contemplated plant site has adequate facilities for furnishing the utility services, much remains to be done before they are available for use.

For the purpose of analyzing the relation of utilities to preparedness in a major emergency, it is convenient to group those industrial plants which are or can be made available for war work, as:

(a) Essential plants,
(b) Non-essential plants,
(c) War plants;

where: (a) includes those plants whose normal production is required in peace or war, (b) those plants which can be converted to essential plants, and (c) plants solely for war purposes.

The essential plants (a) are equipped with utilities and require consideration only when extension is contemplated.

The non-essential plants (b), while equipped with utilities, may require additions or modifications.

The war plants (c) will require complete provision for all needed utilities.

Broadly speaking, the (a) and (b) plants are within or near large centers of population where utilities are to a large extent available. Class (c) plants may be those which a manufacturer agrees to erect in their entirety or those which will be constructed by the Government. In either case, the character of these (c) plants is likely to be such as to call for locations remote from thickly populated districts, and these plants are the ones which to a greater or less extent call for their own utility systems.

The foundation for any analysis of utilities is a knowledge of the requirements of every process utilizing utilities. Therefore, it is essential that all procurement divisions or departments interested in industrial war work should during peace times take steps to ascertain these requirements. Based on these data calculations must be made of the total utilities requirements of each department for the various plants in each of its districts. These two steps are necessary before total demands for utilities for various sections of the country can be determined or even approximated.

The boards to which has been assigned the determination of the facilities available in the various districts for supplying utility service will be furnished, by the departments interested in procurement, with the requirements of these departments. The composite demands must then to the greatest extent possible be balanced against the various utility capacities in the districts by the reallocation of proposed war activities, or by provision for additional utility capacities.

This, it would seem, is as far as the study of utilities, *per se*, can be carried. Of course, in determining plant locations clearances from other boards charged with similar functions in regard to raw materials, fuel and labor would be required before the utility plans could be considered as final.

In the last analysis final clearance on plant allocations would probably have to rest with some coordinating board made up in whole or in part of representatives from the various boards mentioned. Any discussion on this phase of organization in connection with preparedness plans is far beyond the scope of this paper. There is one point,

Water Intake House at Nitro.

however, which it is believed justifies the mention of such a board in connection with utilities. Certainly no one of the various boards mentioned, with the exception of such a coordinating board, could possibly have the authority to eliminate any business or industry on the grounds that it was non-essential. Therefore, it would then seem evident that no board such as a transportation or power board would be able to estimate on any utility capacity to be released in a district by the elimination of a non-essential industry until such a coordinating board had functioned. Unless or until such a board has functioned, any surplus utilities made available by the curtailment of non-essential industries must be regarded as a possible factor of safety.

The policies adopted by the Ordnance Department in regard to utilities are amenable to the general policies outlined, and are illustrative of how one of the agencies charged with preparedness is handling this problem. In general, the Ordnance Department plans to meet its part of a major emergency by first drawing on the available supplies of Ordnance matériel, and second, by war-time industrial production, the latter phase involving the use of plants designated herein as (a), (b) or (c) plants.

Following the last war, steps were taken to obtain and tabulate the unit utility requirements of processes in which the Ordnance Department is interested, and at this time very complete figures relating to unit utility requirements for the numerous processes involved in the fixation of atmospheric nitrogen, the manufacture of smokeless powder and the loading and assembling of ammunition have been collected by the Department. The processes involved in the type (c) plants of this character constitute a large part of the Ordnance Department's demands for utilities.

In collecting these data the maximum and average utility requirements and the cycle of operation were determined for unit operations of the various processes. From these determinations, the maximum and average requirements of the various utilities were figured for typical units. When the Department approached the design of type (c) plants this information was available and the total requirements of each utility in each plant were calculated from these data and a knowledge of plant diversity factor. The Ordnance Department was then in a position to determine types and capacities of apparatus and distributing systems for the various utilities required in the type (c) plant under consideration.

Typical Outside Pipe Line, Nitro.

Part of Boiler Plant During Construction, Nitro.

In the consideration of the construction of utility services for any industrial plant one is faced: first, by the need of utilities during construction and in some cases the construction requirements are the determining factors; second, by the hazards and difficulties which are ordinarily greater in the construction of the utilities than in the construction of other parts of the plant; third, with the impossibility of designing, even in a preliminary way, the major part of the utilities until purpose, size and location have been determined; fourth, by the large amount of preliminary engineering required, which is usually more extensive in the case of utilities than in that required for the remainder of the plant; fifth, by the slow deliveries incident to some of the apparatus, by reason of its magnitude.

These difficulties force one to the conclusion that certain pre-war determinations of (c) plant locations and pre-war designs of such plants are essential to the success of any preparedness plan.

It may seem, from the difficulties that have been enumerated, that the Government is confronted with an insurmountable obstacle in its path toward preparedness, for a large expense would be involved if land were secured

and complete plans prepared for the class (c) plants necessary for a major emergency, but fortunately, the problem is not as difficult as it may appear to be, nor is it impossible for a reasonable solution.

While, as stated, it is impracticable to prelocate and design all class (c) plants, certain locations which would be available for some of these plants are now owned by the Government and skeleton plans and specifications have been prepared or are in the process of preparation for plants at these locations.

As further data are collected the additional utility requirements made necessary by the extensions or modifications to (a) or (b) plants will be tabulated. When this stage is reached, the Ordnance Department's data on utilities requirements will be complete and in a form to be analyzed by the various boards.

To illustrate the progress that has been made in design for type (c) plants, the program of the Ordnance Department for loading and assembling artillery ammunition may be cited. The administrative policy governing loading and assembling plants for a major emergency contemplates a centrally located plant to be built by the Government and a number of smaller plants strategetically distributed among certain Ordnance Districts, to be built by the industries. The site selected for the Government plant was the Savanna Proving Ground on the Mississippi River in Northwestern Illinois.

The general policy of the extent to which the design should be carried was to prepare plans and specifications of sufficient completeness to permit the immediate commencement of work on grading, excavation, trenching, tracks, foundations and other construction of this character. The plans and specifications for structures and apparatus were to be sufficiently complete to permit the immediate ordering of materials and apparatus needed at once or the slow delivery of which, without these plans, would impede progress, and they were also to be complete enough to insure no delay due to the preparation of the detail plans which are to be made after construction is begun.

If we except the utilities, practically all of the plans for structures and the apparatus contained in them were typical, suitable for use at any location. In connection with the design of each of these types a tabulation was prepared showing the average and maximum demand for each utility service required in the building.

The plans include the general design for the power plant with types, sizes and number of boilers, turbo-generators, condensers, pumps and other slow delivery apparatus; outside steam lines; roads and tracks; water intake plans, locations, sizes and types of water mains and laterals; sewer laterals and outfalls; transmission line locations and typicals.

It is believed that this policy of design for Savanna has resulted in the elimination of practically all delay, which would result from incomplete plans either as to their effect on construction progress or on the ordering of apparatus and material. In other words, more complete design would not effect any appreciable increase in speed of construction.

The magnitude of the Savanna project and its importance, even in a major emergency, will be apparent from the following statement of its capacity, for loading and assembling ammunition.

Caliber	*Type*	*Complete Rounds per 24 hours.*
75 mm.	Gun	36,000
155 mm.	Gun	9,600
155 mm.	Howitzer	8,400
8 inch	Howitzer	960
25 to 600 lbs.	Bombs	1,780

The estimated cost of the plant is $20,000,000, and the expenditure on design has been approximately $12,000. This would indicate that plans of such a degree of completeness can be prepared for less than one-tenth of one per cent of the estimated plant cost. These figures are for the complete plant including utilities.

In regard to the other loading and assembling plants necessary for a major emergency and to be located in various Ordnance Districts, the plans for Savanna have enabled the Ordnance Department to furnish these Districts with typical plant layouts based on the typical units designed for Savanna. These plans do not include designs for utility systems which would depend upon location, but attached to and a part of each of these general plans is a tabulation of the average and maximum requirements for the various utility services needed.

The demands of the Ordnance Department represent a very large percentage of the total requirements of all the procurement divisions and departments charged with industrial preparedness, and the type (c) plants in the Ordnance Department represent a large part of the total extra demand for utilities which would be called for in a major emergency.

The nitrate plant at Muscle Shoals, the smokeless powder plant at Nitro, West Virginia, and the contemplated loading and assembling plant at Savanna are representative of Ordnance Department type (c) plants. The importance of utilities in the type (c) plants is in part evidenced by their costs, capacities and the extent of their distributing systems. At Muscle Shoals the cost of the steam and electric power development amounted to 25 per cent of the total cost of the Nitrate Plant No. 2. These costs do not include the Wilson Dam development the power capacity of which was not essential to Nitrate Plant No. 2. The cost of the utilities at Nitro was 27 per cent of the total cost of that project, and the cost of the steam and power development alone amounted to 15 per cent of the total cost. Utilities at Savanna are estimated to cost 27 per cent of the total cost. The electrical capacity required at Muscle Shoals for Nitrate Plant No. 2 was 90,000 kws., at Nitro it was 23,000 kws., and at Savanna it will be 5,000 kws.

Boiler capacity at Nitro was 34,000 boiler horsepower designed to operate at 160 per cent of rating; nearly all of this capacity being for process work and heating. Boiler capacity at Savanna will be 5,000 boiler horsepower designed to operate at 200 per cent of rating.

The water system at Nitro was designed for a distribution of 60,000,000 gallons per 24 hours, and half of this quantity was filtered. The water system at Savanna is designed for a distribution of 15,000,000 gallons per 24 hours, all

of which is to be filtered. These two demands for water are equivalent to the demands from cities of seven hundred fifty thousand and one hundred eighty thousand population respectively.

The following tabulation gives certain data pertinent to the distribution of utilities at Nitro and Savanna, and to some extent shows the importance of this phase of the utilities problem:

Miles of Distributing Systems

	Nitro	*Savanna*
Water	60	82
Steam	14	30
Sewers	55	108
Electric (3 phase circuit)	160	80

It may be said in conclusion, that there are three phases to the utility situation: first, the determination of requirements; second, the determination of existing utilities available to meet the demands; third, the pre-war design of utilities for war plants.

The determination and compilation of data pertaining to requirements and the pre-war design of utilities for war plants properly rests with the divisions and departments interested in procurement. The study of the existing utilities supply, available from public service corporations and municipalities rests with the various boards interested in the specific utilities.

The more completely the policy is followed of allocating war work to the industries in such a way as to avoid overloading the peace-time plant and utility capacities of the individual plants, the less disturbance there will be in the transition from peace-time to war-time operation; the less excess demand there will be on the existing utilities available for service; the less excess work there will be in the design and construction of extensions and modifications to existing plants; and the less necessity there will be for acquiring additional utility capacities by the elimination of non-essential plants with the consequent need for classifying certain industries as non-essential. Thus the methods pursued in the allocation of work to the industries have an important bearing on the available supply of utilities.

Knowing the rate at which the various (c) plants must go into production, the pre-war design of the utilities for these plants must be carried to an extent that will permit the plants to go into operation on schedule time. The cost of such pre-war design for a plant is trivial as compared to the cost of reserves that would be required to offset the loss of even one day's production of the plant.

Who's Who in This Issue

GEN. GUY E. TRIPP, a Vice President and Director of the Army Ordnance Association, is Chairman of the Board of the Westinghouse Electric and Manufacturing Company. During the World War he served as an Assistant Chief of Ordnance in charge of the Production Division.

* * * *

Maj. M. C. Tyler, Corps of Engineers, U. S. A., is the District Engineer at Wilson Dam, Florence, Alabama. Under his direction this gigantic undertaking at Muscle Shoals has been brought to its present state of completion.

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Lt. Col. J. M. S. Waring, Ord. Res., consulting engineer of New York City, served during the World War at Explosives Plant "C," Nitro, W. Va. He has lately conducted a preliminary survey of artillery ammunition loading requirements and facilities for the Ordnance Department.

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Maj. Glen E. Edgerton, Corps of Engineers, U. S. A., is Chief Engineer of the Federal Power Commission.

* * * *

Wm. C. L. Eglin, Sc.D., is President of the Franklin Institute of Philadelphia and Chief Engineer of the Philadelphia Electric Company. Members of the Army Ordnance Association will remember the address by Dr. Eglin at the Seventh Annual Meeting of the Army Ordnance Association at Aberdeen Proving Ground last year.

* * * *

Maj. G. R. Young, Corps of Engineers, U. S. A., is resident engineer of the Board of Engineers for Rivers and Harbors.

Brig. Gen. Colden L'H. Ruggles, Ord. Dept., U. S. A., is an Assistant Chief of Ordnance and is also Chief of the Manufacturing Service of the Ordnance Department. General Ruggles' article was presented by him as a statement representing the Ordnance viewpoint before the President's Aircraft Inquiry Board.

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Maj. R. R. Nix, Ord. Dept., U. S. A., is a member of the Planning Branch, Office of the Assistant Secretary of War.

* * * *

Dr. H. H. Lester is Research Physicist at the Watertown Arsenal Laboratory and is a well known authority on the radiography of metals. Mr. R. H. Aborn, who collaborated with Dr. Lester, was formerly Research Assistant at the Laboratory. Part IV of their article, "The Behavior Under Stress of the Iron Crystals in Steel," concludes the series. This treatise will be published in pamphlet form, copies of which can be procured upon application to the Editor.

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For the benefit of those whose interest lies particularly in the supply and maintenance of ordnance, we begin, in this issue, a regular department under the title, "Theater of Operations," which will be edited by Maj. T. A. Clark, Ord. Dept., U. S. A. Major Clark is in charge of the War Plans Section, Field Service, Office of the Chief of Ordnance.

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We take pleasure in announcing that Maj. Pelham D. Glassford, F. A., U. S. A., is now a member of the editorial staff of ARMY ORDNANCE. Major Glassford will be in charge of the illustrations in this journal.

Hydro-Electric Development Under the Federal Water Power Act

By

Maj. Glen E. Edgerton, Corps of Engineers, U. S. A.

HYDRO-ELECTRIC development in the United States is very largely dependent upon the attitude of the national government. Its authority over such development is derived from the control of the territory and other property belonging to the United States, the right to exercise jurisdiction over navigable waters in the interests of interstate or foreign commerce, and the complete control of boundary waters, as an adjunct to the treaty-making power. If a water power development affects or would affect one of these three interests, it falls within the paramount jurisdiction of Federal government.

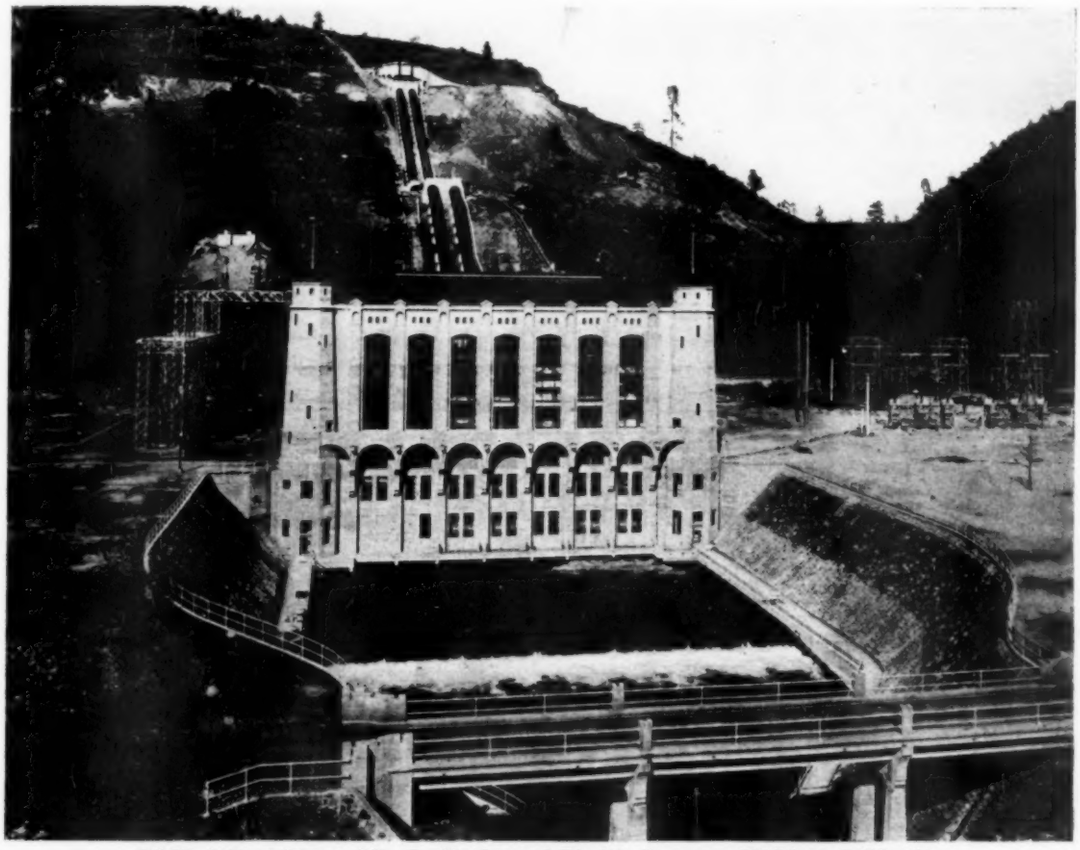
It might seem, at first thought, that only a moderate proportion of the total water power resources of this country would be within the scope of authority drawn from such sources, but that is not the case. In 20 of the 48 states of the Union, the United States retains title to national forests, national parks, Indian reservations, unappropriated domain, etc. The percentage of the area owned by the Government varies from one-half of one per cent to ninety per cent of the gross area of the particular states and aggregates nearly forty per cent of the combined area of the twenty states. Most of these reservations and public lands lie in the mountain area of the West, and they contain, within their boundaries, the major water power resources of the country. The water ways that are actually navigable constitute a relatively small proportion of the power resources, but since the consent of the Government is required for operations conducted on the tributaries of a navigable waterway affecting the navigable capacity of the main stream, the jurisdiction of Federal authority extends, on this ground alone, to most of the important rivers of the country and to many smaller streams as well. The importance of boundary waters in power development is sufficiently indicated by mention of the St. Lawrence River, the best power river on the continent.

Altogether, it is safe to say that the water power resources over which the Federal government has paramount jurisdiction amount to eighty-five per cent of the total of such resources in the United States, or about 34,000,000 kilowatts out of a total of 40,000,000 kilowatts on the basis of power available fifty per cent of the time. The total of the water-power resources under the control of the Government is sufficient to supply three times the total quantity of electrical energy consumed in the United States in 1925. It is not to be inferred, however, that the development of these extensive water-power resources will ever reach a stage in which the entire demand for electrical energy will be supplied from water power. At present, about sixty-four per cent of the total output of electrical energy in this country is produced by fuel power and the proportion has been increasing at the rate of about one per cent per year during the last five years, notwithstanding the rapid growth of hydro-electrical developments during the same period.

Big Creek Power House No. 1, Southern California Edison Company.

On the headwaters of the San Joaquin River, California. A type of high head development in the War West. Installation: Two 17,500 KVA. generators connected to two 10,000 H. P. overhung Pelton wheels. Operating head 2,131 feet.

The first really comprehensive legislation to provide the necessary Federal authority for water-power development on navigable streams and public lands was the Federal Water Power Act, approved June 10, 1920. Earlier legislation had been limited to specific legislative authorizations in individual cases and to general laws treating public lands and navigable streams separately. These laws provided for an indefinite tenure on the



Pit No. 1 Powerhouse of the Pacific Gas and Electric Company, Pit River, California.

Mitchell Dam of the Alabama Power Company, Coosa River, Alabama.

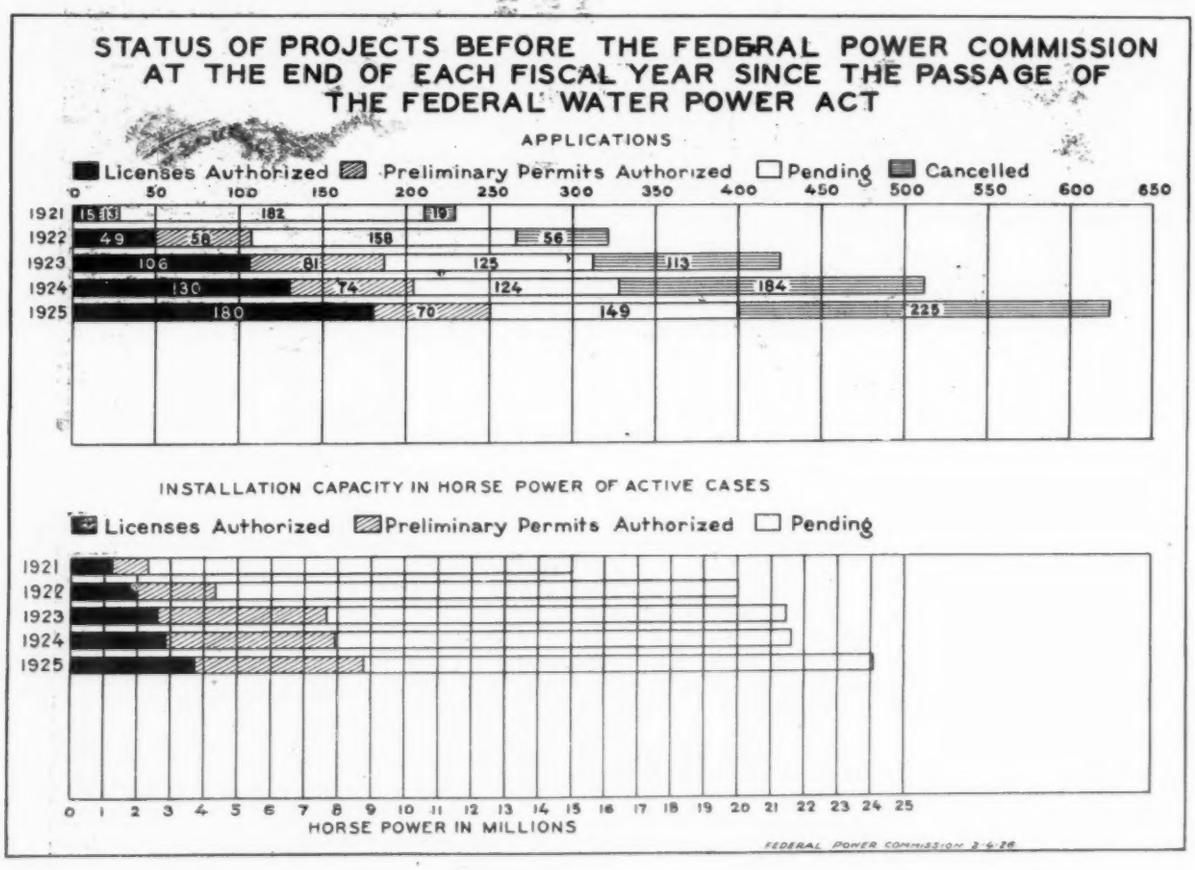
public lands and expressly reserved the right to repeal the enactments relating to navigable rivers; while uncertainty as to the requirements that might be imposed in both cases and frequent changes in executive policy detracted still further from their effectiveness in providing for the development of the water powers under the control of Congress.

Legislation for the correction of this situation was under consideration for upwards of ten years before its enactment was finally effected. The long delay during its discussion may have been exasperating to many of the interests concerned, but the final result has worked so successfully for the past five years, that there is reason to believe the prolonged discussion was by no means profitless, and this law stands out as a carefully prepared and really effective conservation measure, among many hasty ones that serve the purposes of conservation less effectively. Be that as it may, the Federal Water Power Act is a true conservation measure, since it permits the development of resources that are not depleted by development, while securing to the Federal government ample but not extravagant return for the use of the public property involved and for the cost of administering the act itself and providing fully for the protection of the legitimate rights and interests of the general public.

The administration of the Act is entrusted to the Federal Power Commission, which consists of the Secretary of War, Secretary of Interior and the Secretary of Agriculture, who are the heads of the executive departments directly concerned with the administration of the navigable waterways, public lands, and national forests which water power projects may involve. The Commission is authorized to issue licenses for not more than fifty years for power developments involving any or all of these three national resources.

Licenses are issued only for projects that are fully adapted to the comprehensive development and the most beneficial uses of the resources involved, and the Commission exercises supervision over the plans and the construction of the project to insure their safety, suitability and adequacy for their purposes. Applicants must be citizens, domestic corporations or municipalities who have complied with the laws of the states in which the projects may be located, to the full extent necessary to permit the applicants to effect the purposes of the proposed licenses. Other things being equal, applications by municipalities are given preference over all others. Each applicant must furnish satisfactory evidence of his readiness and ability, financial and technical, to carry out the project and to make effective use of the power to be developed. Definite times for beginning and completing construction are laid down in each license.

After the issuance of a license, the licensee is required to carry out the construction program laid down in the license and thereafter to maintain the project works at all times in a condition for efficient operation. He is required to keep accounts under supervision by the Commission to show currently his net investment in the project, to pay reasonable charges for the use of Govern-


STATUS OF PROJECTS BEFORE THE FEDERAL POWER COMMISSION AT THE END OF EACH FISCAL YEAR SINCE THE PASSAGE OF THE FEDERAL WATER POWER ACT
APPLICATIONS
Licenses Authorized
Preliminary Permits Authorized
Pending
Cancelled
0 50 100 150 200 250 300 350 400 450 500 550 600 650
1921 15 13 182 19
1922 49 56 158 56
1923 106 81 125 113
1924 130 74 124 184
1925 180 76 149 225
INSTALLATION CAPACITY IN HORSE POWER OF ACTIVE CASES
Licenses Authorized
Preliminary Permits Authorized
Pending
1921
1922
1923
1924
1925
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
HORSE POWER IN MILLIONS
FEDERAL POWER COMMISSION 2-6-26

ment land or structures, to reimburse the Government for the cost of administration of the Act and to maintain suitable depreciation reserves. After the first twenty years he is required to set aside a portion of any earnings in excess of a reasonable return upon the legitimate capital expenditures for the amortization of such expenditures. The rates charged and services rendered by a licensee

Main Plant, Niagara Falls Power Company; Capacity 452,000 H. P.

operating as a public utility are subject to control by the Commission unless controlled by an appropriate state agency, and if the licensee is engaged in interstate business, the issuance of securities pertaining to his project is also subject to the control of the Commission under like circumstances.

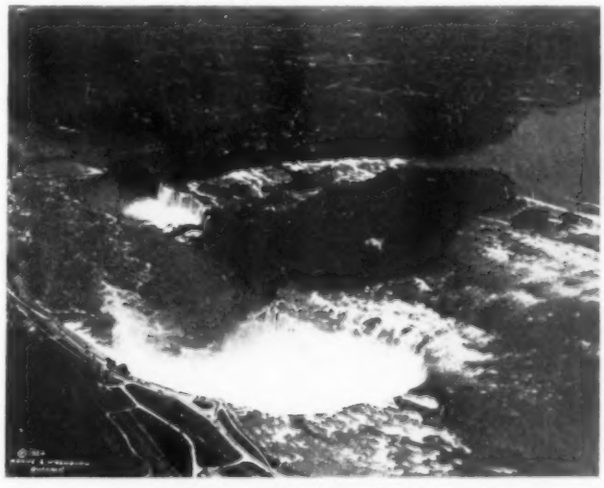
The terms of each license are definite and fixed during the period of the license, protecting the licensee against the possibility of revocation or adverse modification by administrative action or changes in the law. Upon the expiration of a license, it may be renewed, or the property may be transferred to a new licensee or taken over by the United States upon payment of the net investment and appropriate severance damages.

In addition to licenses of the type just indicated, which are issued for all important projects, the Commission issues less formal licenses for minor projects (not in excess of 100 horsepower) and for minor parts, such as transmission lines, pipelines, and parts of reservoirs, where navigation is not affected and only an insignificant proportion of the project area involves Government lands. In such licenses many of the requirements of the standard licenses are waived, but a license is always issued for a definite period which may never exceed fifty years.

Preliminary permits for periods of not more than three years are also issued, upon application therefor, to prospective licensees who desire to secure and maintain priority of application for a license for the development of specified power sites while their possibilities are being investigated and complete plans for their development are being prepared. Preliminary permits require the permittee to establish gaging stations and to secure records of steam flows, to determine the extent and capacities of prospective reservoirs, to estimate the power capacities of the projects, to investigate foundation conditions, to design the project works best adapted under the law to the developments under consideration, and to submit a proper application for license therefor before the expiration of the period of the permit. Special requirements desirable in the public interest may also be imposed, and a permit generally contains reference to any unusual conditions that it can be foreseen are likely to be inserted in the license, if one is issued. Permits are not transferrable, and during the life of a permit, applications by persons other than the permittee that could encroach upon the project for which the permit was issued, will not be considered. If the terms of a permit are complied with and an application for a license is submitted in accordance therewith, the applicant is given preferential consideration, exclusive as against any other applicant, by the Commission.

To fix definitely the status of any project upon any tributary of a navigable waterway, a "declaration of intention" may be filed with the Commission showing the nature and magnitude of the proposed works, whereupon the Commission investigates their probable effects upon the interests of interstate or foreign commerce and renders a formal decision as to whether or not Federal jurisdiction attaches. If the finding is affirmative, the works can not be constructed legally until a license has been secured; otherwise, the consent of Congress to the proposed construction is given by express terms of the Act.

It may be seen, therefore, that the Federal Water Power Act provides adequately for the development of government controlled water power resources by private capital under terms which fully respect the capital investment, insure the proper uses of such resources, protect the public against the possibility of gouging by the evasion of public supervision, and prevent the permanent alienation of these water power resources from governmental control.



Niagara Falls from the Air.

It should be noted, however, that the authority of the Federal Power Commission extends to *water power* developments only. Even the use of government lands or the crossing of a navigable stream by a transmission line cannot be authorized by the Commission, if fuel power alone is the source of the energy to be transmitted.

At the time of the passage of the Federal Water Power Act about 1,300,000 horsepower had been developed in water power projects affecting public lands or navigable waters under the provisions of the legislation then in existence. Within four months after the passage of the Act, 260 applications for power developments had been filed under its provisions, involving a primary capacity of more than 11,000,000 horsepower. Since the first rush of applications under the new and favorable legislation, the number and aggregate capacity of the applications filed has increased consistently, evidencing a sustained and a healthy growth of water power development. The chart on page 332 shows graphically the status of all applications received at the end of each fiscal year of the Commission's existence.

On February 1, 1926, 691 applications had been received, of which 445 were in an active status as licenses, permits, or cases still under consideration. The leading state in point of the number of active projects is California, while the leading state in aggregate power capacity is New York. Thirteen states contain no projects in an active status before the Commission at present.

Two hundred and eight licenses have been issued and are now in effect. About half of them are for transmission lines and other minor parts of projects. Eighty-nine of the complete projects under license, with an aggregate installation capacity of 2,781,128 horsepower, are now constructed or under construction.

Wide ranges of capacities and varieties of design are included among the projects. Installed capacities of individual developments range from 3 horsepower to 518,300 horsepower. Operating heads range from about 8 feet to 1910 feet. Only one plant, that of Henry Ford & Son, Inc., on the Hudson River, has propeller type turbines. The highest head plant is that of the El Dorado Power Company on the South Fork of the American River in California. The Oak Grove plant of the Portland Electric Power Company on the Clackamas River, in Oregon, contains reaction turbines operating at 890 foot head, which is believed to be the highest head at which wheels of this type have yet been operated. The 65,000 kva. turbo-generating units installed in the plant of the Niagara Falls Power Company still represent the maximum attainment in the capacity of a single unit.

Generally speaking, the extremely high head plants are located in the far West. East of the Rocky Mountains, large developments are usually effected by the utilization of great volumes of water at low and moderate heads. Storage giving complete regulation of stream flow is more frequently obtainable in the West, where the desirable reservoir sites have not all been pre-empted for other uses, than in the East, where the high costs of flowage rights, particularly those growing out of railroad locations, limit the possibilities of power development on many otherwise attractive power streams. As a result, partial regulation or run of stream plants, with installations greatly exceeding the primary capacities of the sites, are common in the East, where the secondary power is valuable in connection with the extensive distribution systems supplied mainly from fuel generating stations; while in the West, a high degree of stream flow regulation is frequently obtained and the ratios of installed to primary capacities are usually smaller.

Although the prospects for hydro-electrical development have been greatly improved since the passage of the Federal Water Power Act, the impression should not be given that all artificial impediments to progress have been removed. The fact is that development of some of the most important water powers in the country is being delayed by controversies founded more on politics than on economics. The issuance of Federal authorization for power projects in the Colorado River drainage basin is now in suspense on account of circumstances resulting directly from the disagreement of the Colorado River states over the distribution among themselves of control of the waters of the Colorado. Power development on the St. Lawrence must remain at a standstill until a scheme for power and navigation development acceptable to the United States and Canada can be devised. This problem, fortunately, is now under intensive study by an international board of engineers. Power developments on the Columbia have until recently been suspended pending the determination of the requirements of possible irrigation projects. In this case, however, suspension has probably not operated to delay the ultimate development, which depends upon the growth of adequate markets, not now in existence, within transmission range of the great power sites on this river. A committee of the Senate is at present considering a resolution to suspend the application of the Federal Water Power Act to the Tennessee River and its tributaries until the disposition of the government-owned plants at Muscle Shoals is decided upon. The purpose of this resolution is to remove the other power sites on the Tennessee from the control of the Federal Power Commission to that of Congress, which would probably postpone the development of these sites indefinitely. Other cases could be cited to show the difficulties in which the development of some of our best water powers are entangled, but in all cases the difficulties encountered spring from other sources than defects in the basic law.

Five years experience in the administration of the present Water Power Act has shown that its provisions are sufficiently attractive to private capital to induce the development of hydro-electric resources at a rate much greater than any previously attained in this country and with ample protection to the interests of the general public. Some of the greatest water power resources of the country, however, remain in a status that prevents their development at present, owing to the interposition of unnecessary obstacles to the full application of the provisions of the Federal Water Power Act, while legislative measures for still further restriction of its application are being urged. Important national resources and public interests are involved and future legislative action should be directed toward the promotion of the development of water power resources by the removal of the existing difficulties, rather than its discouragement by the creation of new obstacles.

Training the Staff for Operating Modern Power Plants

By

Wm. C. L. Eglin, Sc. D.

ABOUT fifty years ago the first generating stations to supply electricity for the diversified needs of our communities were established. During this period, extremely rapid developments have taken place, not only in the total amount of power available, but also in fuel economy—the electrical output per pound of coal having been more than quadrupled.

The principal advances in fuel economy have come about during the last twenty years. A tremendous growth in the size of stations and of major units has gone hand in hand with corresponding increases in the number of plant accessories and auxiliaries, and in the complexity of their arrangement, to make possible these improvements.

Twenty years ago, the turbine was just becoming definitely fixed as the coming form of steam prime mover for electric generation. Turbo-generator units had been installed outstripping in size the largest engine sets, although quite insignificant in comparison with those of the present. Generating station practice in operation and design was just outgrowing many features retained from engine days.

In the modern station, the stern necessity of economizing in fuel consumption has led to the use in standard station designs not only of the relatively enormous turbines, boilers, and condensers now available, but, also, of literally dozens of plant accessories and auxiliaries unknown twenty years ago. Stage bleeding, re-heating, air pre-heating, air-cooled and water-cooled furnace walls, deaerators, heat interchangers, and numberless other subjects could be mentioned which are now in the general vocabulary of all power station engineers, but which twenty years ago would have been as so much "Greek." The trend of design has been particularly in the direction of replacing by mechanical or electrical devices, such as remote reading indicating and recording instruments, remote control and automatic con-

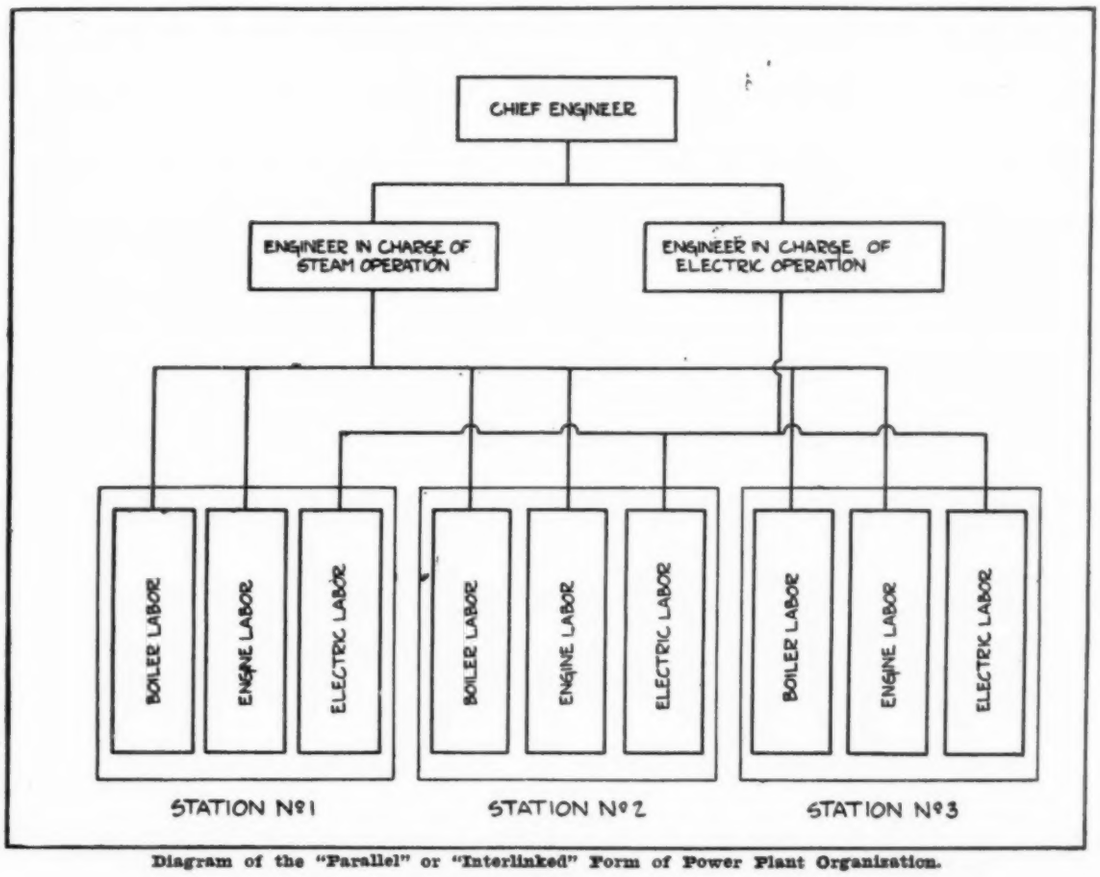


Diagram of the "Parallel" or "Interlinked" Form of Power Plant Organization.

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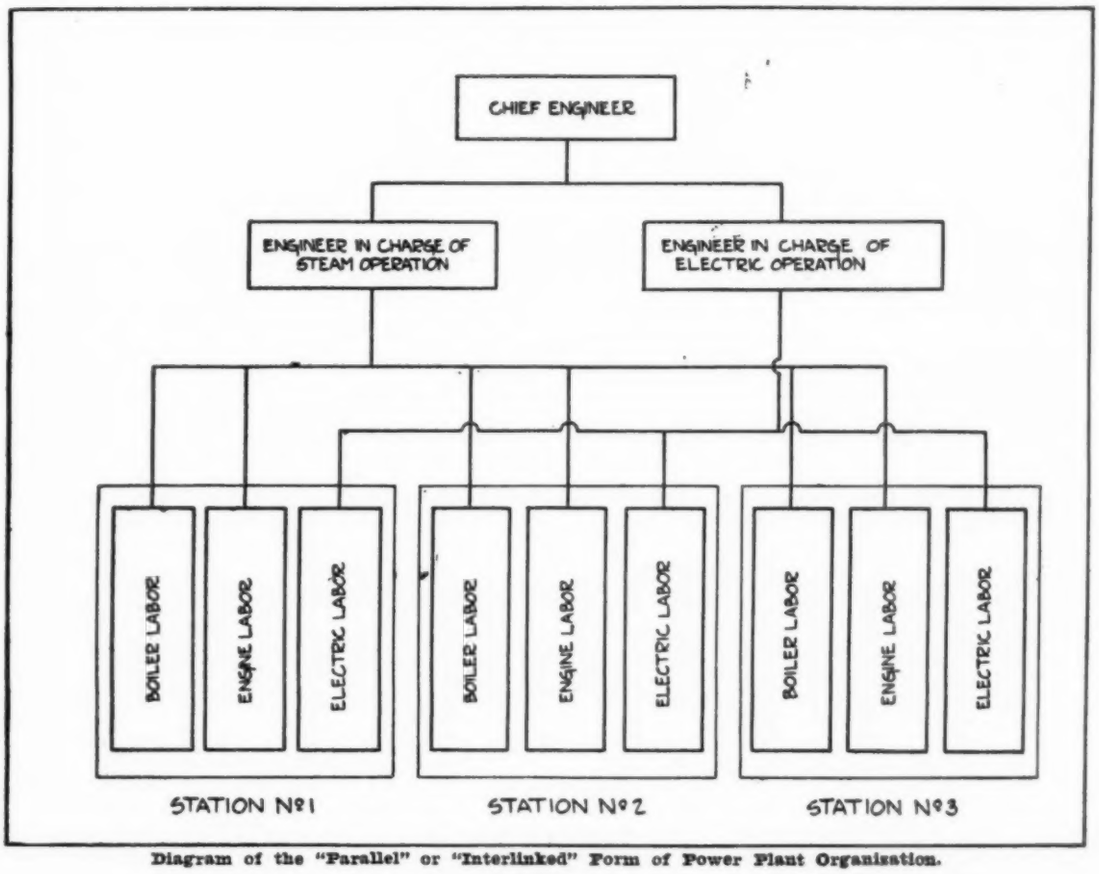

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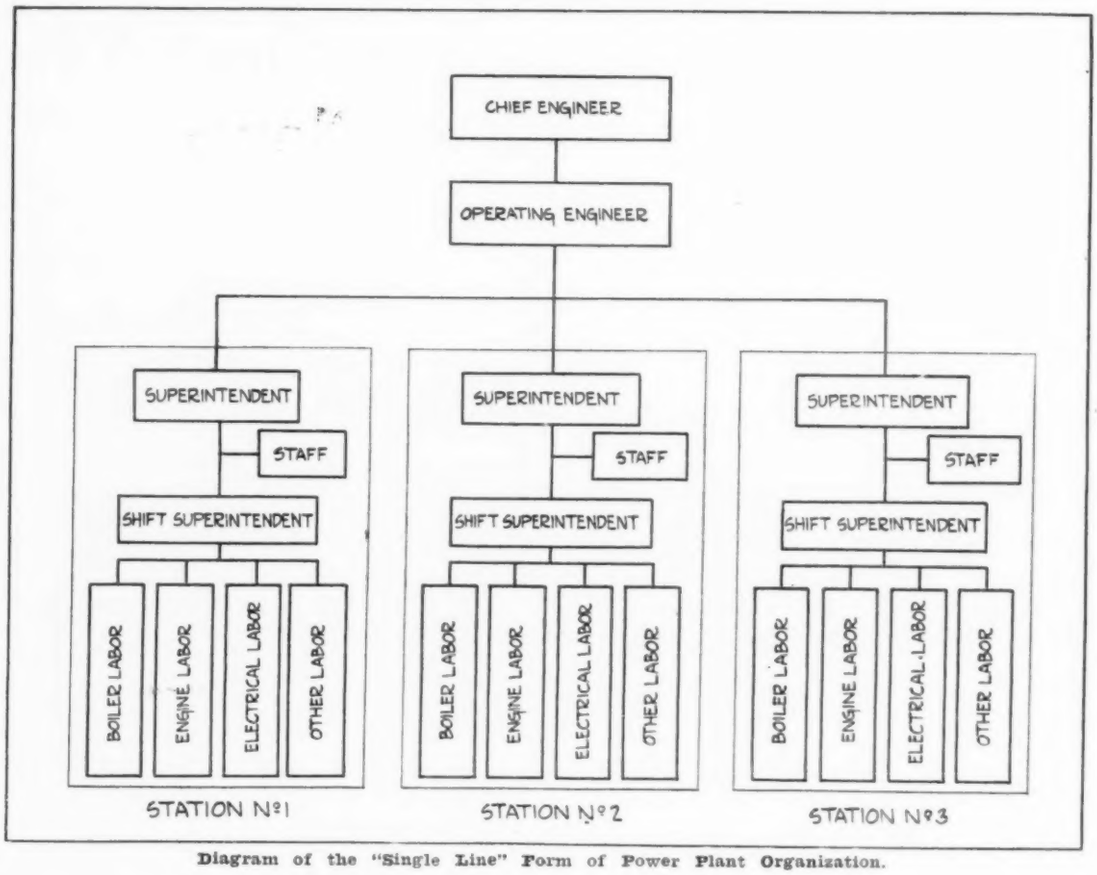
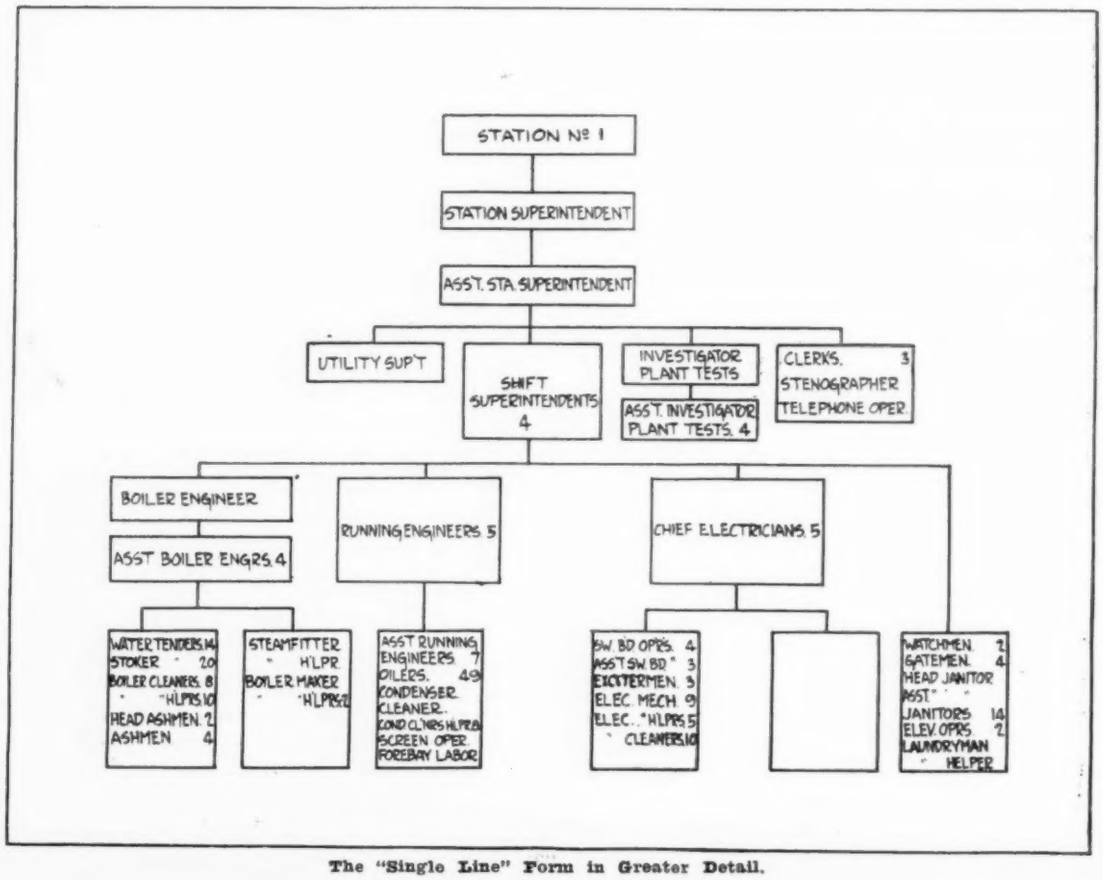


Diagram of the "Single Line" Form of Power Plant Organization.



The "Single Line" Form in Greater Detail.

trol, and mechanical stokers, those functions of the plant force involving continued heavy exertion and monotonous repetition or concentration.

These tendencies have made possible from the physical side the economical performance of our modern stations. However, the original design of any station fixes only its best potential performance and not by any means its actual performance. It has always been true that to realize the full capabilities of a station for economy, reliability and continuity of service, requires the most intelligent and interested efforts of a well-trained force.

The more exacting nature of the present-day requirements in station operation points definitely to the need for employing a higher class of labor, in general, and for developing the potential abilities of this labor through systematic training.

The first of these demands is being met, both actively, through specific selection in employment, and automatically, in that station operation, now robbed of its old terrors of long hours, monotony and hard labor, appeals to a much superior class of applicants for work. The opportunities for service and personal progress offered by the electrical power industry have attracted, among others, a great many young and earnest engineers. The excellent records of economy, reliability and continuity of service achieved by the large power companies have resulted largely because they have satisfactorily solved the problems of building up, from this initially good material, a personnel especially trained in their duties, and of providing means for advancing employees to higher and more responsible positions, as they become qualified.

The older methods of the journeyman and the apprentice, in earlier years almost without competition, have now been largely superseded by vocational training, based upon standard text, reference and instruction books. The mechanical engineer, the chemist and the electrical engineer have joined together in developing a highly trained type of power house engineer; and graduates in all of these fields are found among the leaders in the large power houses.

The most valuable aid in developing the staff of the modern power plant is to give to the operator the fullest possible information regarding the machinery and apparatus under his care, and to provide, for his guidance, instructions which have been carefully prepared, and which are revised from time to time as experience may dictate changes.

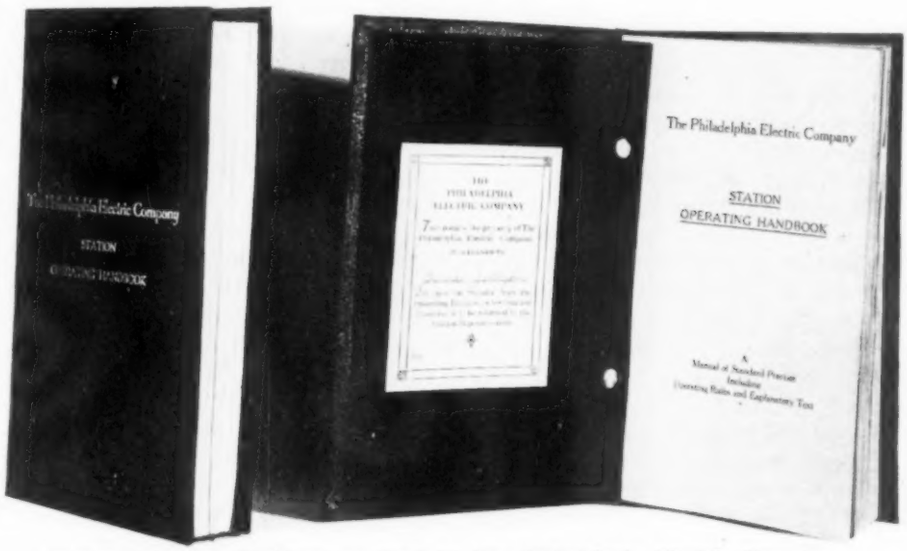
It is difficult to give proper training in an organization of unsuitable form.

It hardly needs to be said that the organization of the successful power station must be along military lines; there must be, if the lines of authority are followed back, a single directing head. However, the military form of organization may have many variations, not equally desirable, from either the operating or the educational viewpoint.

A schematic diagram of the organization form which might be termed "parallel" or "interlinked" is shown in Fig. 1. This form is still in effect in many places in spite of the inherent weakness of its divided responsibility.

While close cooperation between the steam and electric executives may build up a working understanding, there is danger that friction and trouble will develop at any time, and especially in emergency.

In Fig. 2 is shown schematically, and in greater detail in Fig. 3, a form of organization which overcomes the objections just mentioned. This form might be termed the "single line" by reason of the single line of authority direct from the lowest position of the plant to the chief engineer of the system. Under this form of organization, the entire authority in each station is centered in the superintendent. He settles all questions of plant policy and directs their execution. His authority is delegated by him to the assistant superintendent, of course, and also to the shift superintendents, one of whom is on duty at every hour of the twenty-four; thus there is always in the station one man who is recognized by the entire station force as having been assigned complete authority. The advantages of this organization form are quite evident from a most casual consideration, but no one is entirely qualified to judge how much superior it is who has not at some time operated under each form.



Station Operating Handbook as Used by The Philadelphia Electric Company.

It is fortunately found that the organization more desirable from an operating standpoint also lends itself more readily to systematic training of employees. In practically all of the companies operating modern stations written standardized instructions for operation have been developed to some extent. The practice of one company in this regard will now be described.

In this case the instructions take the form of a "Station Operating Handbook" prepared by the system operating

management with the cooperation of the station superintendents and other experts in the various branches of operation, so that it represents accurately the best standard practice as developed in the stations of this company. The book is arranged in loose-leaf style for several reasons. Prominent among these reasons are: first, so that individual pages may be readily revised and replaced as practice changes, or as errors are discovered; second, so that the book may be separated into sections, each dealing with one branch of the plant work. The purpose of this separation is that the men in the lower positions of any branch are given only the section pertaining to their own work, unless they desire to broaden themselves by studying the principles of other branches, in which case copies of the complete book are made available to them. The complete book is distributed to the men in the upper grades of the various branches, those who are either already in positions where they require knowledge of the complete operating rules, or in line for such positions. The handbook has been written up in parallel fashion; specific rules for operation have been collected together, and following a section giving explanation or comment upon these rules.

The handbook, either as a whole or merely a single section, is enclosed in a stiff cover, each cover being numbered and assigned to a particular employee, and then required of him at the termination of his service. (See Fig. 4.)

In addition to the rules and text pertaining to the purely operating side of the requirements for employees in the various positions, the Station Operating Handbook also contains lists of standard text and reference books which form a foundation for any further study which may be desired along more technical lines. The handbook was written and the entire system of training developed with the purpose of leading employees to become interested in further study upon their own initiative of the matters presented in it.

The personal study by each man of the section of the handbook applying to his particular work is supplemented by advice and assistance from the executive staff of the plant. A man must become thoroughly grounded in the rules pertaining to his own position before he can have advancement to the upper grades and better rates in that position, or promotion to a higher position.

One of the great advantages of a system of training such as this is that the new employee at whatever point he may enter the organization is given standardized instructions upon which to base his work, and after he has familiarized himself thoroughly with those pertaining to his own job, the handbook then offers opportunity for him to compare the requirements in his own position both with those for the positions immediately above him and those in collateral lines, giving him opportunity to determine whether he would feel more at home and be capable of more rapid progress in one of the other branches of the plant organization. If the latter is the case, since the boiler plant, turbine plant, electric plant and other labor are all under the common authority of the station superintendent, it is easy for him to make the desired transfer. Such a transfer may also be made upon the initiative of the man's superiors if they feel that his work would be more valuable elsewhere.

Since this company happens to be located in a city noted for its wide night school and other technical educational opportunities, the company does not maintain any direct classes of instruction in technical subjects. The employee is rather encouraged to pursue technical courses in the recognized schools already established. As an added incentive to such study, the company, upon satisfactory completion of an approved course by the employee, refunds a stated portion of the tuition expense to him.

On account of the close knit character of the organization under this form, intercourse between employees of the various branches is of the friendliest and the opportunities for absorbing information are correspondingly better than in the case of the "parallel" form of organization. Examinations are made by each man's superiors at intervals rgarding his familiarity with the operating handbook and the miscellaneous requirements for his work. In this way, the superiors can readily observe which men in the organization are deserving of more detailed attention with a view to possible future promotion.

The value of establishing such a type of training as this is observable to the trained eye in examining the operating cost records and analyzing plant performances, but probably its most spectacular success is shown when a new station is to be placed in operation. A few months before the schedule starting time of the new station men are selected for the various key positions in the organization of the new station. These men are either to be transferred from the same grade in their present stations, or to be promoted from a lower grade to their new positions. In either case, they are distributed throughout the existing stations under special intensive training with a particular view to the new positions they are to take up; consequently, when the new station is to be started a thoroughly trained skeleton organization is ready to step into it with full knowledge of the exact duties that will be required of them.

To conclude then, briefly, the modern type of training which I have had in mind to describe takes the employee at whatever point he makes his entrance into the organization, grounds him thoroughly in his own job, advises him of the educational and performance requirements of the jobs directly above his, and also of those in collateral lines, so that he may remedy his deficiencies, and also that he may decide along which path he wishes to press his fortunes, instructs him before he occupies it in the duties of any other position to which it may be desired to transfer or promote him, and enables him to be of the greatest assistance to those about (and particularly below) him, in developing themselves in turn.

The Electric Power Survey

By

Maj. G. R. Young, Corps of Engineers, U. S. A.

THE Chief of Engineers, acting for the War Department, is at present conducting a war plans study known as the Electric Power Survey, which has certain special features of considerable interest.

The necessity for the survey developed as a result of our experience during the World War. A valuable pamphlet on this subject, entitled "The Power Situation During the War," was prepared by Col. Charles Keller (retired, formerly of the Corps of Engineers) and published by authority of the Secretary of War. The facts, briefly, are that the demand for power resulting from our own entrance into the World War, coming on top of the heavy load previously caused by our manufacture of raw materials for the Allies, was too much for the power producers at certain centers, such as Niagara Falls and Pittsburgh. Very critical conditions at these points might have developed, and were avoided only by hasty and able emergency measures. It was evident that steps should be taken to anticipate the character of and need for such measures in another emergency. Shortly after the war, therefore, this work was undertaken by the Chief of Engineers, and was placed under the direct charge of Colonel Keller, who at that time was Resident Member of the Board of Engineers for Rivers and Harbors. He was succeeded in that capacity first by Col. G. M. Hoffman, and thereafter by the author.

It should be emphasized at the outset that the power survey is a form of procurement study, of the same general class as those being carried on by the different procurement bureaus of the War Department under the supervision of the Assistant Secretary of War. It is, however, a specialized form. When we study the procurement of, let us say, field guns and their ammunition, not only is the study made by the Ordnance Department, but that branch itself would in time of emergency be the purchaser of the material in question. It is thus, in general, practicable to assign individual factories to individual bureaus, for study in peace time and for supply in an emergency. In the case of electric power, however, no one bureau, and in fact no one Department, will be the sole purchaser, and the organization of the industry is such that individual power plants cannot, in the general case, be allocated to a specific bureau or Department. The study has been assigned to the Corps of Engineers because we have a permanent organization for carrying on river and harbor improvements and other civil works, which covers the entire territorial United States, and possesses some fifty-odd offices, located at important cities. We are therefore in close touch with important civilian interests, and are able to do the work with little or no expense by using the spare time of our office forces.

The survey fell naturally into three parts:

First, To obtain such data on the power situation as would enable the preparation of an emergency plan;

Second, To prepare the emergency plan;

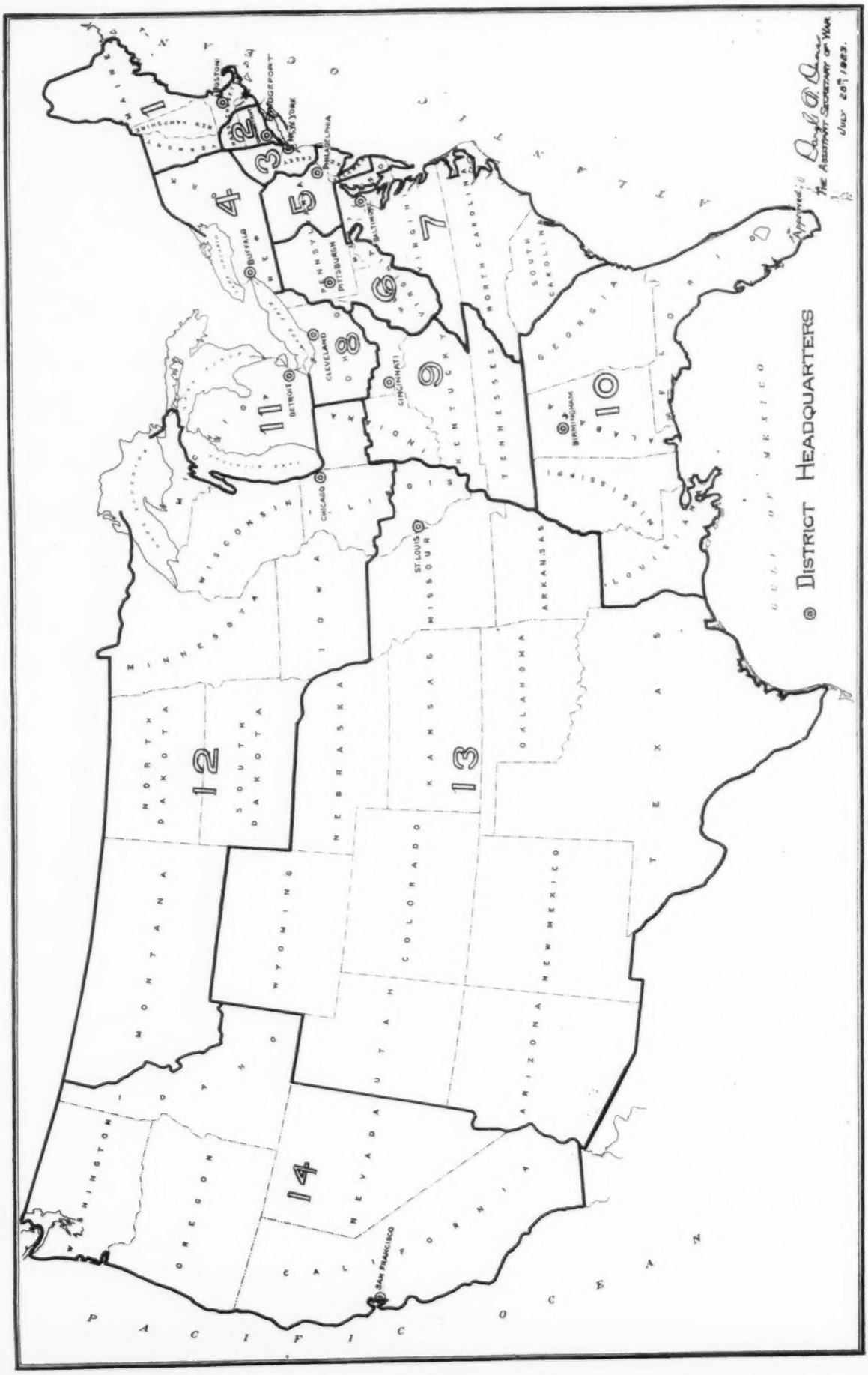
Third, To keep that plan up to date.

The first two parts of the work have been completed. The third is of course a permanent job involving annual revisions. I will discuss these three parts in order.

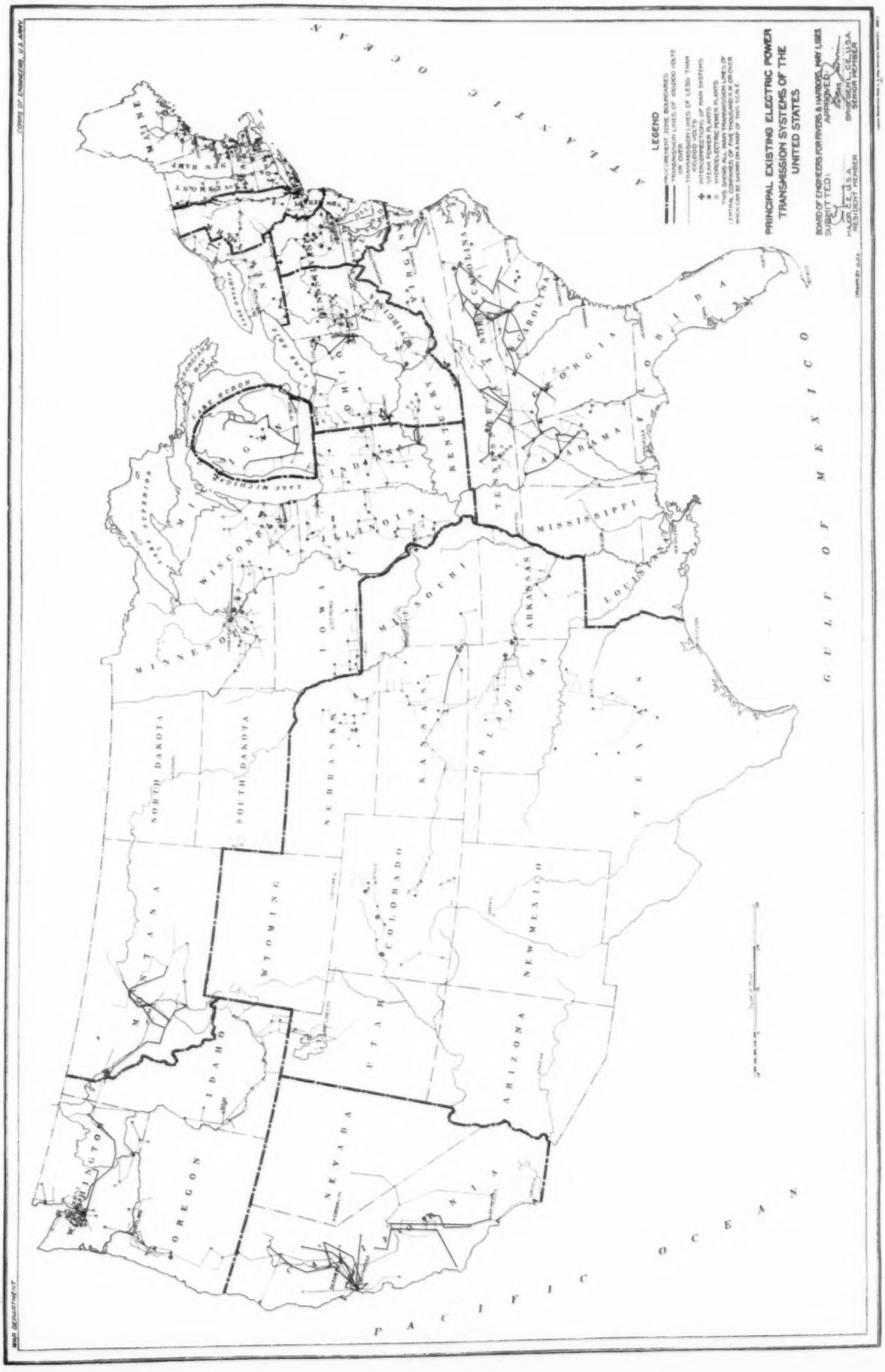
A start was made on the preliminary studies in 1921. During the war we had made contact with the officers of the principal power concerns in the country, and with such central organizations as the National Electric Light Association. The proposed work was discussed in detail with them, and we had the benefit of their careful advice. In December, 1921, instructions were sent to engineer districts throughtout the country to obtain certain specified information regarding the principal power producers, their existing installations and their plans for future expansion. A great deal of work was involved in obtaining these data, and since, as stated above, it had to be done by our regular office forces, it was understood at the outset that one or two years would probably be required to gather the information. The year 1922 and the first half of 1923 were thus occupied.

In the Spring of 1923, another circular was sent calling for the results of the study. This circular was much briefer than the previous one, the idea being to obtain, from the information already collected, only that which was essential to the preparation of a plan by the central office, and sufficiently brief to be capable of digestion by that office. Reports under these instructions were submitted in 1923 from the engineer districts throughout the country.

The basic data collected, concerned almost exclusively the larger central station companies throughout the country, the limit being set, with certain exceptions, at those which produce, or purchase and distribute, at least 5,000 kw. (peak load). For each of these companies we obtained the location and capacity of power-houses; the peak load on the system; the annual production in kilowatt hours; the transmission net down to sub-stations; the interconnections with other systems; and the expansion plans of the companies. (The latter item is confidential, and is used only to obtain summaries and consolidated figures.) Except for expansion plans, these items of information, taken individually, were already more or less available to the public, but this is the first time, to my knowledge, that they have been assembled in one place with the particular intention of giving a bird's-eye view of the national power situation. Having once collected them, it is a small matter to keep them up to date. All that is necessary is to send a



War Department Procurement Districts.



Principal Existing Electric Power Transmission Systems of the United States and Power Zone Boundaries.

few blueprints of maps, and photostats of tables, to the companies concerned, get them to make changes thereon indicating new developments, and consolidate these changes in the district offices.

Having obtained the basic data, the next task was the development of an emergency plan based thereon. The *first* requisite for such a plan is that *it deals with the situation now existing.* Therefore, while the data which we study are much the same as those studied in so-called "super-power" investigations, our plans are not "super-power" plans, in the sense that we base them on what may or should come about in the course of ten or twenty years. The problem we are required to solve is, what should be done under present conditions in the event of an emergency occurring now. If the situation is materially changed within ten years, as it undoubtedly will be, our plans will be changed correspondingly.

The *second* requisite is, that the plan must be coordinated with the other procurement plans being made under the supervision of the Assistant Secretary, since, as I have said, this is simply a procurment plan of a specialized character. For ordering procurement work, the country has been divided into fourteen districts (see page 340), and the policy is one of decentralization to these districts. This fact, and sound principles of organization as well, make it desirable that the emergency power organization be likewise decentralized into territorial zones, and that they coincide as far as possible with the other procurement districts.

But, as a *third* requisite, the areas thus selected should be *natural power zones.* By a natural power zone I mean an area which is, to the maximum degree, self-contained as regards production and consumption of power, and which to the minimum degree imports or exports power from adjacent areas. The advantage of this is obvious. In so far as a zone is thus self-contained, it is practicable for the emergency zone administrator to deal with the problems of power distribution without reference to higher authority, except in matters of policy. But if the zone boundary cuts across an important power system, so that part of its power is consumed in one zone and part in another, any dispute as to the distribution of power must be handled by agreement between the zone administrators, or by reference to higher authority, that is to the central administration in Washington. In every case there will exist a certain amount of power transmission across the zone boundary, but this should be kept to a minimum.

The *fourth* requisite is that we shall attain our end with the least disturbance of industrial conditions, and the least burden on private companies, in both peace time and war time. In peace time this means that we want to annoy the industry as little as possible with requests for information, notably that type of elebarote questionnaire which is a source of irritation to busy men, and which, if it results in anything, results in a mass of information so elaborate that no one can digest or use it. Our policy must rather be, to present our problems to the industry, obtain its advice as to the best solution, and check this advice against our own knowledge of the military situation and exigencies of war. Thus each of us, the power industry and the Department, will be working in the field which it best understands, as distinguished from a method whereby the Department would attempt to arrive at a conclusion from masses of data which only an expert familiar with the local situation can interpret.

In war time we need an organization capable of dealing with emergencies wherever they arise, and so far as it is humanly possible, we need advance plans for dealing with them. But we emphatically do not wish to impose on the industry a complicated system of regulation unless it is needed. My own view is that, if tomorrow we entered war on the same scale as the World War, crises in the production of power would arise, at the most, at only a very few points. Even in 1918 they arose at only a few points, and at that time the industry was already strained by three years of large-scale production for the Allies before our own additional load came on to it. If, therefore, in war, a power center is functioning satisfactorily, and meeting all demands, and will apparently continue to do so, the task of the local administrator is to sit tight and let it run, in the meantime keeping in close touch with conditions. When an emergency arises, which the power interests and others concerned cannot themselves deal with, that will be the time to put our plans into effect so far as needed.

These four desiderata form the basis of our plan.

Territorial Organization

On page 341 is given an extremely condensed view of the major transmission systems which shows the boundaries of the power zones selected. The latter are a compromise between the Procurement District boundaries established by the Assistant Secretary, and the requirement for keeping natural powers areas intact. The most important departure from coincidence with Procurement Districts is in the southern Ohio Valley (District No. 9). As a procurement district, No. 9 is no doubt excellent, but it is not at all suitable from the power point of view. Tennessee is logically a part of the southern Appalachian power group, and Ohio must be dealt with as a whole and should preferably have east Kentucky added to it. District No. 9 has therefore been broken up among three power zones. In the case of Districts Nos. 3 and 4, the boundary line had to be shifted further west, following the natural division between the power centering on Niagara and that centering on the Adirondacks and the Hudson valley. And District No. 14 is so large, and from a power point of view is so distinct at its two ends, that it has been divided into two zones.

The following are the power zones; also the installed capacity and production, in round numbers, of the companies studied, in each:

Power Zone.	Headquarters	Installed Capacity kw. or kva.	Consumption kwh.
New England	Boston	1,690,000	2,550,000,000
New York	New York City	1,960,000	4,650,000,000
Philadelphia	Philadelphia	1,060,000	2,020,000,000
Southeastern	Charleston, S. C.	1,805,000	2,830,000,000
Buffalo	Buffalo	675,000	3,510,000,000
Pittsburgh	Pittsburgh	2,340,000	5,830,000,000
Detroit	Detroit	830,000	1,320,000,000
North Central	Chicago	2,260,000	4,490,000,000
South Central	St. Louis	885,000	2,180,000,000
North Pacific	Seattle	695,000	1,710,000,000
South Pacific	San Francisco	2,390,000	4,050,000,000
	Total	16,590,000	35,140,000,000

We have in general used, as zone headquarters, the same cities designated by the Assistant Secretary as Procurement District Headquarters. There are two exceptions. One is the North Pacific zone, in which, as it is only a part of a

Procurement District, we had to designate a new headquarters. Seattle was selected. The other exception is in the Southeastern power zone, where for administrative reasons, and on account of the combining of Procurement Districts 7 and 10, the best location for a peace time headquarters is Charleston, S. C. Also, where one of our zones includes two procurement districts, we must in some manner keep in contact with the procurement organization at the headquarters city where our zone headquarters is *not* located. This will probably be accomplished by a suitable liaison agent. An example is the New England zone, where our headquarters would be at Boston, with a liaison agent at Bridgeport.

The next point for consideration is the functioning of these power zones. Our mission is to see that, in time of emergency, all procurement bureaus of the Government, and all manufacturers working for them, obtain all the power they need, while at the same time the essential needs of civilian life are also met. Therefore the theoretically ideal method would be to find out what the war time needs of such procurement bureaus will be. But this is a lengthy task. The branches of the War Department are even now engaged in working out in detail their war time needs in material and allocating them to manufacturers. They have not yet converted these material needs into terms of power. The Navy Department must also be considered, as well as such organizations as the Shipping Board, which in certain emergencies might bring a great load on the nation's industry. It became evident that, if we waited until we knew with fair accuracy what the war time power demands would be, we might have to wait a long time. It was therefore decided not to make a study of how to meet specific demands which are as yet incapable of being estimated, but to make a study of *the maximum power demands which could be met within specified periods, and the means of accomplishing it.* We would then be in a position to say to the procurement branches of the Government, regarding a certain power zone, "Such and such is the *greatest* amount of power we can deliver to you. If you find that you need less, we can cut down on the war time expansion program. But if you find that, under your present plans, you need more, those plans must be changed, because in that particular zone there is no more to be had."

What we are working to, therefore, is the following information for each power zone: Assuming that war were to occur today, what is the maximum amount of electric power which can be made available, by the important central station companies, in addition to what they now have available, within periods of 6 months, 12 months, 18 months and 24 months from the outbreak of the war? What installations, what priorities on electrical material and on fuel, what interconnections, and what financing will be necessary to bring this about? And how much of this excess power could be delivered, in the specified periods, to designated critical points within the zone, or to adjacent zones; by what means, and at what cost?

Approval of this line of investigation was given last year. Very shortly we will be in a position to answer the above questions for the entire country. Strictly speaking, we are in a position to do so now: that is, the information from the field has been arriving at my office during the past month or two, and is now all at hand. I hope to be able to consolidate it in a few weeks. Keeping it up to date will, as stated above, be a simple matter.

During peace time the study will center in the office of the Chief of Engineers. Peace time activities of the power zones will be in charge of engineer district and division officers. Our districts are much more numreous than are the power zones, and their boundaries are located with a different end in view. An operating field office has been selected for zone headquarters in each case, and will have the assistance of such other offices as lie in the same zone. The zone headquarters will be charged with the studies along the lines above indicated, with the necessary continuing liaison with the power industry, with similar liaison with the peace-time activities of the procurement districts, and with the creation of skeleton organizations to be filled out in an emergency.

In war time it is likely that there would be created in Washington a Power Administration, which would probably be extra-bureau and even extra-Departmental, as were the Food and Fuel Administrations in the late war, since its activities would concern numerous bureaus and departments. Its agencies in the field would continue to be the power zones, which would retain their present boundaries, and in all or nearly all cases their present headquarters. The central organizations would establish policies as to priority among power users and similar matters, but the enforcing of these policies would devolve principally on the zones. The zone administrators would at once be vested with full powers in the matter of restricting and diverting the use of electrical power, and would arrange for expansion, interconnections, and whatever else would be necessary to increase the supply. Their exercise of these powers would however depend entirely on how the situation developed; they would not interfere with the normal organizations and activities of the industry except as problems arose which that industry could not itself settle. That such problems will arise, is proven by the expansions in the World War.

The operation of the war-time administration will require executives, acting for the Government, who for convenience should preferably be commissioned officers. It is our desire to have a group of reserve officers at all times familiar with and available for this work.

In concluding, reference should be made to the attitude of the power industry throughout the investigation. On our part we have attempted to give it as little trouble as possible; and on its part, it has met us with a cordiality of cooperation even beyond our expectations. All the important power men with whom I have talked, fully understand and I believe fully approve the end we have in view. I want to emphasize this, because plans for Federal administration or supervision of industry in time of war are often supposed to be highly unpopular with the industries themselves. This I am convinced is not the case with the plan now proposed. The power companies learned, eight years ago, that in a serious emergency they were likely to meet difficulties which could only be solved by Government agencies, and by the Government issuing orders, and accepting responsibility for orders, which they themselves could not issue. They are only too glad to envisage such agencies and administrative action to assist them to carry the load in another great national emergency.

Antiaircraft Defense

By

Brig. Gen. C. L'H. Ruggles, Ord. Dept., U. S. A.

THE most effective defense against enemy aircraft is offensive action of our own aircraft. If we could count on absolute command of the air, not only general command, but command at all times day and night and in all places at the front and behind the lines, the need for antiaircraft defense would be greatly decreased. But aviation is a very mobile force, and by skillful maneuvering the enemy aviation, even if inferior in power to our own, may secure a temporary local command of the air; and this doctrine is recognized by aviators who would never admit that they would be absolutely helpless against a superior air force. By its mobility enemy aircraft may at any time, but particularly at night, slip across our front and penetrate far into our territory in spite of the superiority of our own air power. If our air force is inferior to that of the enemy, or becomes so at any time, the need for supplementing it by antiaircraft defenses is obvious.

Brig. Gen. Colden L'H. Ruggles, U. S. A.,
Assistant Chief of Ordnance.

One of the inherent advantages of an air force is its mobility, and it should be relieved whenever possible from being tied down to the defense of particular installations on the ground—among which may be included our own airdromes. In many instances ground installations to be protected from hostile aircraft will be located so close to the front lines that enemy bombers or attack planes can pass over our lines and reach their target before our own aviation can get from the ground into the air in a fighting formation and climb to a fighting altitude. To insure a continuous, instant defense of such installations at all times, day and night, we must either provide an antiaircraft defense, or keep our own pursuit planes in the air above these installations at all hours during the day and night. Only in the defense of the most critical areas should any part of our air force be immobilized for the defense of ground installations, and the part so immobilized should be held to a minimum.

The continued building up of antiaircraft defenses by all the combatants in the World War is the best testimony that antiaircraft defense is a valuable and necessary adjunct to the other combatant arms in time of war. This testimony is confirmed by the thought now being given to antiaircraft defense by the leading countries of Europe and the efforts they are making to increase the efficiency of antiaircraft fire by training of antiaircraft personnel and by improvement in antiaircraft matériel.

Functions

It is believed that the principal functions of antiaircraft defense are as follows:

(1) To provide immediate protection to important ground installations against bombing and attack planes.

(2) To provide immediate protection for bodies of troops, including artillery, against low flying aircraft.

(3) To drive off or destroy enemy planes in the absence of friendly aircraft.

(4) To break up enemy aircraft formations so as to allow defending planes to engage the disordered attack at an advantage.

(5) To protect friendly aircraft when they are engaged at a disadvantage.

(6) To indicate enemy aircraft to the defending aircraft.

(7) To form the sole means of defense when the geographical position of vulnerable points precludes all possibility of adequate warning being given to de-

fending aircraft in time for them to attain their fighting altitude.

Weapons

In order to carry out the above functions, the following types of antiaircraft weapons are now believed to be necessary: Cal. .30 machine guns on antiaircraft mounts; Cal. .50 machine guns on antiaircraft mounts; 37-mm. full automatic guns on antiaircraft mounts; 3-inch antiaircraft guns on mobile carriages; 3-inch and 4-inch antiaircraft guns on fixed carriages; search lights and listening devices.

Effectiveness of Antiaircraft Defense as Indicated by World War Records.

The best measure of the effectiveness of antiaircraft artillery is undoubtedly found in the records of the World War period, since these records were obtained under actual combat conditions.

No antiaircraft artillery was in existence prior to the World War. During the war this class of artillery had to be rapidly developed to meet the development of aircraft. Not a great deal could be accomplished in this connection during the first period of the war since shortages of other types of artillery also existed. During this period field guns mounted on wooden carriages or improvised structural mounts were used for antiaircraft guns, and the fire control instruments consisted of paper charts and improvised plotting boards. Notwithstanding the crude antiaircraft guns and instruments which were then available antiaircraft artillery was found to be of great value.

The following table which is taken from official reports is believed to be of interest. It gives a comparative statement of the number of airplanes brought down by the Aviation Service on certain fronts and the number of planes brought down by antiaircraft guns on the same fronts.

Nation.	Planes brought down by Aviation Service.	Planes brought down by A. A. Guns.
Italy	540	129
Germany	6554	1520
France	2000	500

Thus the antiaircraft guns accounted for about one-fifth of all the planes which were destroyed by the three countries mentioned. In this connection it should be remembered that destroying enemy aircraft is only one of the functions of antiaircraft artillery as set forth above, and the official War Department records indicate that antiaircraft defense fulfilled the other missions which were assigned to it quite as effectively. A further search of the War Department records indicates that the following expenditure of ammunition was made per plane destroyed.

FRENCH RECORDS

Year.	Rounds per plane brought down.
1916	11,000
1918	7,500

BRITISH RECORDS

1917	8,000
1918	4,550
Last part of 1918	1,300

The American service is officially credited with 58 enemy planes and an average of 605 shots required to bring down each plane.

The interesting point to be noted in the figures of ammunition expenditures in terms of planes brought down is the very rapid increase in the apparent effectiveness of fire notwithstanding the improvement in the speed and the ceiling of aircraft during that time. This was undoubtedly due almost entirely to the improvements in antiaircraft guns and fire control instruments which were being made as rapidly as possible throughout the World War period. It should also be pointed out that the planes officially destroyed cannot be in any way considered as the full measure of effectiveness of this arm of the service. To this must be added a knowledge that solely by its presence antiaircraft defense required the enemy to fly higher than was advantageous for his mission; that frequently, enemy planes were turned back by the antiaircraft defenses from attempting their missions; that frequently enemy planes which succeeded in returning within their own lines after having been under antiaircraft fire were so badly damaged by it that they were destroyed in landing; that the friendly aviation was frequently warned by antiaircraft fire of the presence of an enemy not seen by them and so either saved from an unequal combat or given a chance to attack advantageously; and last but not least, a very precious service was rendered to the rear areas and to the zone of the interior by the warning given of the passage of enemy night bombers.

I found during my recent trip abroad, during which I spent considerable time investigating the subject of antiaircraft defense, that the leading European countries are convinced of the necessity for antiaircraft defense, and that the belief is general that the efficiency of this defense will rapidly increase due to improvement in training methods and in matériel.

Defense of Paris

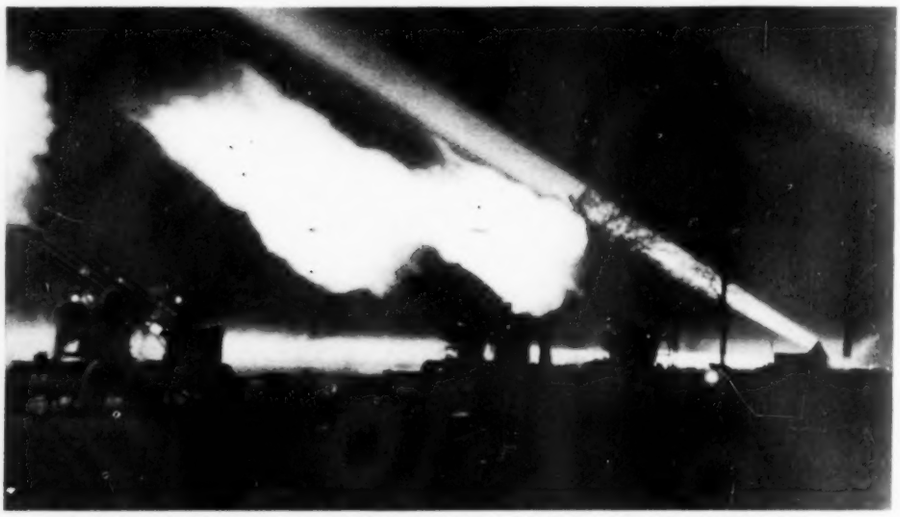
Some general information* and details concerning the organization of the antiaircraft defenses of Paris will be given because it is believed that this is the best example of the measures which must be taken in the defense of a modern city against attacks by air raiders. The story of the defense of Paris gives one a very vivid picture of the position in which a modern city might find itself if subject to attacks from enemy aviation.

During 1914 and 1915 there was no bombardment of Paris by airplane. Night bombardment effected from a distant base was limited to Zeppelins, and the defense, therefore, was at first organized exclusively against them. In consequence, the aviation, which was the most efficient weapon against dirigibles, was largely developed. At this stage the antiaircraft artillery defenses of Paris consisted of a few guns only, and the defenses were not definitely organized until 1915, while for a considerable time thereafter they consisted only of improvised matériel. Towards the middle of 1916 the menace of night bombardment by airplanes in large numbers began to make itself

*Source of information—"The Defense of Paris Against Airplanes During the War," by E. Villaret, Major, C. A. Compiled from official French records.

felt. In 1917 the enemy having built some high-powered Gothas sent them to England.

The consequent heavy bombardment of London furnished an example that clearly indicated to the French the necessity of reinforcing the defenses of Paris. Therefore, early in October 1916 the antiaircraft defense of Paris took definite form, a regiment of antiaircraft artillery being definitely assigned to it. At about the same time, some Zeppelins, which were headed toward England, lost their bearings and were stranded in France. Four were brought down. This raid almost definitely marked the failure of the Zeppelin. From then only the airplane



Night Firing, Battery B, 61st Coast Artillery (Antiaircraft), Grand View, Va.

night bombardments were to be feared, and early in 1918 the Gothas paid their first visit to Paris. At this time the defense of the aerial zone just over the city itself was assigned to aviation, while the exterior defense was confined to the antiaircraft artillery. After March, 1918, big airplane raids were made on Paris by night. Reconnaissance was made during the day by a few German airplanes and single machines flew over Paris in daylight at altitudes from 5,000 to 6,000 yards. At night and generally on moonless nights large bombing planes attacked Paris in successive waves at altitudes varying from 2,500 to 4,500 yards and in squadrons of from 50 to 70 planes.

For the day defenses French Aviation made permanent patrols outside the zones of action of the artillery. Batteries were reinforced and grouped to permit great concentration of fire.

As for the night defense, the cooperation of aviation with artillery presented great difficulties and even dangers. It became quite difficult to recognize the nationality of the planes in the field of fire. Also sound ranging on which the fire was based was seriously hindered. The batteries were also delayed in opening fire. To avoid these difficulties it was decided in March, 1918, to leave the field free at night to the antiaircraft artillery and to use airplanes only in case the artillery proved inadequate.

In order to keep the antiaircraft defenses thoroughly informed, a permanent service of observation of aircraft of all kinds was conducted by a system of special sentry posts called "lookout posts" all through Paris and extending far to the front. This system permitted all movements of the enemy planes to be followed as soon as these planes came within fifty miles of Paris.

The means of defense employed by the antiaircraft defenses of Paris in 1918 were of two kinds; first, passive means; and second, active means.

The passive means consisted either of placing obstacles along the probable route followed by the enemy, which constituted for them a permanent and invisible danger, such as balloons; or of misleading them by means of camouflage of the terrain, such as the use of smoke and false objects. For this defense the following matériel was used: A number of kite balloons with various anchorages were distributed at various points in the vicinity of Paris and in Paris itself. On the alert these balloons were sent up to high altitudes to block most of the routes habitually followed by the enemy. Smoke generated by special devices was emitted, thus permitting the masking at the most propitious moment of the guide posts which might be used by the enemy. Next to the organization of camouflage by smoke generators, there was added the establishment of false objectives consisting of frail structures and false scenery installed at various distances from Paris at points not vulnerable. The ingenious disposition of lights enabled the normal activity of all these false objects to be simulated. Finally the lighting of Paris and its environments was reduced to a strict minimum. After February, 1918, in case of the alert signal, darkness was practically absolute.

The active means of defense consisted of a methodical and continual engaging of enemy planes in order to impede their progress and to inflict injury upon or to destroy them, using aviation, antiaircraft artillery, searchlights and machine guns.

The results obtained by the active and passive antiaircraft defenses of Paris are shown in Table I. This table was compiled from reports checked immediately after each raid. From the table it is seen that of the 483 planes employed by the enemy in attacks on Paris

TABLE I.

Night Raids by Enemy Planes in the Paris Area During 1918.

Night of	Number of Enemy Planes in raid	Number of Planes succeeding in flying over Paris itself	NUMBER OF BOMBS DROPPED ON PARIS						Planes Brought Down by the Defense
			Planes	Kilograms					
				300	100	50	10	5	
Jan. 30-31	30	11	2 7 1 1	2	7 1 1	35 2	11 20	12	1 Plane brought down near Chelles.
Mar. 8-9	60	3	1 2		2 2	2 10	6 2	2	
Mar. 11-12	70	5	4 1		4	16 1	18		4 Planes, struck by AAA, could not reach their own lines and had to come down in the region Chateau-Thiery, Soissons La Ferre, Milon.
Apr. 1-2	7	1	1			5	7		
Apr. 11-12	2	2	1 1	1		6			
Apr. 23-24	1	None							This plane was obliged to land near Nogent-l'Artaud.
May 15-16	30	None							
May 17-18	3	None							
May 21-22	10	1	No bombs						1 Plane, disabled by AAA, landed near Verberie.
May 22-23 2 attacks	40	1	1		1	5			
May 27-28	15	None							
May 29-30	5	None							1 "Gotha" violently engaged by AAA, brought down in flames at Plessis-Belleville.
May 30-31	6	1	1	1		1		4	
May 31-June 1 2 attacks	6	None							
June 1-2	11 (2 of which are Giant Planes)	2 (on periphery of Paris only)	1 1	1	1	4			1 of the Giant Planes violently engaged by 4 AAA btys., brought down at Betz. The crew of 3 officers and 7 men set fire to the plane and are made pris.
June 3-4	7	None							
June 6-7	20	2	1 1		2	1 1	10 30		
June 13-14	3	None							
June 15-16	10	1	1			7			
June 26-27	20	1	1			6			
June 27-28	40	2	1 1		1 1	5 5	5 4		2 Planes struck by the AAA were brought down: one of them near Villers-sous-Coudun, the other in Eagle Forrest. A 3rd plane, disabled, managed with great difficulty to get back to own lines flying at very low altitude.
June 28-29	2	1	No bombs						
June 30-July 1	4	None							
July 1-2	3	None							
July 18-19	10	None							
Aug. 1-2	10	None							
Aug. 15-16	10	None							
Sept. 15-16	50	3	1 1 1		1	4 7 7	6		2 Planes brought down. One by direct hit which cut it in two while it was coming toward Paris at an altitude of 3200 meters: one of its motors was blown off and it came down straight just north of Gonesse. The other plane fell in the Comiegne Forrest.
1918	483 planes	37 Reached Paris and dropped		5	24	130	119	18	And lost 13 Planes brought down.

during 1918, only 37 succeeded in flying over Paris and 13 of these were brought down by the antiaircraft defenses.

Tests at Fort Tilden, 1925.

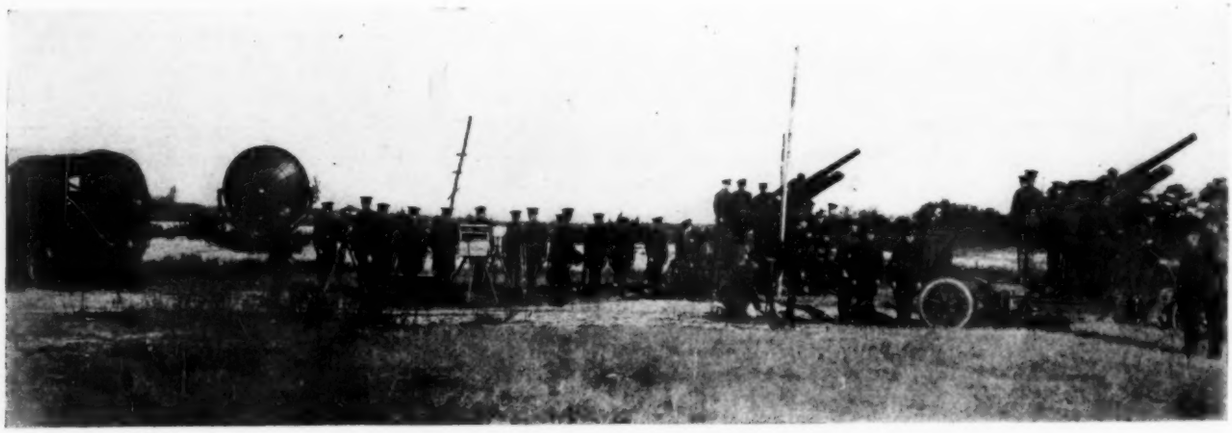
As previously stated, the best measure of the effectiveness of antiaircraft artillery is to be found in records of the World War period. In times of peace when it is impossible to fire guns under combat conditions, the only means of judging the effectiveness of a weapon is by target practice records and proving ground tests and by calculations based on target practice records and proving ground reports.

The 62nd Coast Artillery Regiment, Antiaircraft, was encamped at Fort Tilden during the Summer of 1925, and

TABLE II.

Battery B, 62nd Coast Artillery.

	3-INCH A. A. GUNS																						
	PRELIMINARY									RECORD									TEST				
	Day							Night		Day					Night				Day	Day	Ngt.		
	May .. to June 1	June 2	June 22	July 9	July 29	August 11	Total	July 29	Total	June 17	June 23	June 29	July 1	Total	August 12	August 24	August 27	Total	June 11	July 9	August 18	Total	Total
Total shots fired	162	83	64	102	107	178	696	10	10	178	189	167	*207	741	192	106	189	487	85	223	196	504	2438
Shots fired at moving targets		83	64	87	96	168	498	5	5	173	182	157	190	702	187	97	180	464	75	198	177	450	2119
Hits on actual moving targets		1	0	0	3	5	9	0	0	4	0	0	0	4	2	4	22	28	0	6	0	6	47
Targets shot sown by gun fire		0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	3
Targets lost for any cause		0	0	1	0	0	1	1	1	0	1	0	0	1	0	0	0	0	1	0	0	1	4
Hits on hypothetical target		6	0	1	2	6	15	1	1	9	9	8	1	27	9	4	14	27	2	10	0	12	82
Per cent of hits		7.2	0	1.15	2.1	3.57	3.01	20.0	20.0	.52	4.95	5.1	.53	3.84	4.8	4.11	7.78	5.81	2.57	5.05	0	2.67	3.87
Hits per battery per min.		3.08	0	.53	2.48	1.48	1.16	12.8	12.8	2.28	1.64	1.55	.30	1.51	2.08	4.36	4.34	2.84	4.11	2.68	0	.96	1.55
Hits per gun per min.		0.77	0	.13	.62	.36	.29	3.22	3.22	.57	.41	.39	.07	.38	.52	1.09	1.06	.71	1.02	.67	0	.24	.49
Hits per thou. rounds—actual		12.	0	0	31.	29.7	*21.9	0	0	23.1	0	?	0	*7.7	10.7	41.1	122.	60.2	0	30.6	0	*16.0	*38.2
Hits per thou. rounds—Theor.		72.	0	11.5	21.	35.7	30.1	2.00	2.00	52.0	49.5	51.	53.	38.4	48.	41.1	77.8	58.1	25.7	50.5	0	26.7	38.7
Rounds fired per battery per min.		28.4	34.4	46.3	53.6	38.8	38.5	64	64	44	33.3	30.5	56.8	39.4	43.6	48.4	56.0	48.8	15.8	53.1	43.6	36.1	40.0
Rounds fired per gun per min.		7.1	8.6	11.6	14.4	9.7	9.6	16	16	11	8.4	7.6	14.2	9.8	10.9	12.1	14.0	12.2	3.9	13.3	10.9	9.0	10.0
Slant range yards (average)		3900	4655	5010	4315	4400	4456	2900	2900	4580	3800	3800	5130	4328	3716	4400	3625	3914	4505	4260	4700	4455	4224
Horizontal range yards (average)		3400	4200	4400	4005	3950	3991	2500	2500	4470	3260	2680	4630	3807	3166	3648	3325	3379	4100	3800	4215	4038	3695
Altitude yards (average)		2000	2000	2410	1590	1960	1992	1460	1460	1960	1864	2312	2200	2084	1840	1642	1455	1646	1820	1900	2219	1979	1914
Average ground speed of plane—M. P. H.		65	60	65	60	60	62	45	45	60	60	62	52	58	61	50	54	55	55	65	70	63	59.2
Actual firing time—minutes		2.92	1.85	1.88	1.79	4.47	12.91	.07	.07	3.93	5.49	5.15	3.33	17.90	4.3	2.0	3.22	9.52	4.73	3.70	4.06	12.49	52.89



An Antiaircraft Battery Preparing to Fire.

TABLE III.

Battery C, 62nd Coast Artillery.

	3-INCH A. A. GUNS																								
	PRELIMINARY									RECORD										TEST					
	Day							Night		Day								Night		Day	Day	Day	Ngt.		
	May 1 to May 25	May 26	June 2	June 22	July 30	September 10	Total	July 30	Total	June 3	June 4	June 17	June 18	June 22	June 24	July 1	Total	August 11	Total	June 10	July 9	July 11	August 18	Total	Total
Total shots fired	156	52	71	73	31	81	461	105	105	56	90	117	74	185	179	183	884	80	80	97	122	125	197	541	2074
Shots fired at moving targets		52	71	73	26		222	100	100	52	77	106	74	185	179	183	856	80	80	82	122	115	191	510	1768
Hits on actual moving targets		9	3	0	0		12	0	0	1	1	0	11	10	17	4	44	0	0	0	0	1	4	5	61
Targets shot down by gun fire		0	0	0	0		0	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	3
Targets lost for any cause		0	0	0	0		0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	2
Hits on hypothetical target		2	2	6	1		11	13	13	3	2	1	5	8	4	11	34	6	6	1	8	7	25	41	105
Per cent of hits		3.3	2.8	8.2	3.85		4.98	13.	13.	5.77	2.59	.94	6.76	4.32	2.24	6.00	3.97	7.5	7.5	1.22	6.55	6.08	13.1	8.05	5.95
Hits per battery per min.		1.0	1.32	3.49	1.6		1.51	6.	6.	2.17	1.03	.36	2.7	1.84	1.12	2.46	1.70	3.08	3.08	.42	3.16	2.78	7.15	3.75	2.46
Hits per gun per min.		.25	0.33	0.88	.4		.38	1.5	1.5	.54	.26	.09	.7	.46	.38	.61	.42	.77	.77	.10	.79	.69	1.79	.94	.61
Hits per thou. rounds (actual)		173.	42.	0	0		54.2	0	0	19.2	13.0	0	149.	54.	95.	21.9	55.4	0	0	0	0	8.7	21.0	9.8	34.9
Hits per thou. rounds (Theor.)		33.	28.	82.	38.5		49.8	130	130	57.7	25.9	9.4	67.6	43.2	22.4	60.0	39.7	75.0	75.	12.2	65.5	60.8	131.0	80.5	59.5
Rounds fired per Bat. per min.		24.2	25.2	42.4	42.4		30.4	43.3	43.3	37.5	40.0	38	40	42.4	50	41.	42.8	41.04	41.04	34.2	48.2	45.4	54.8	46.6	41.5
Rounds fired per gun per min.		6.1	6.3	10.6	10.6		7.6	10.8	10.8	9.4	10.0	9.5	10	10.6	12.5	10.25	10.5	10.26	10.26	8.6	12.15	11.3	13.7	11.6	10.4
Slant range yards (average)		4550	4600	4830	3675		4414	3475	3475	4200	4100	4460	3800	4830	4960	4830	4454	3970	3970	5020	4490	3200	3260	3992	4250
Horizontal range yards(average)		4000	4100	4300	3350		3937	3100	3100	3637	3750	4100	3560	4200	4580	4500	4061	3330	3330	4700	4000	2800	2580	3520	3804
Altitude yards (average)		1960	2000	2200	1375		1884	1400	1400	2100	1800	1800	1600	2146	2340	2200	1998	2000	2000	1750	2030	1700	1900	1845	1900
Average ground speed of plane		60	65	53	60		59			68	60	65	57	53	62	70	62	55	55	60	65	63	75	66	58.3
Actual firing time (minutes)		2.11	2.82	1.72	.62		7.27	2.31	2.31	1.38	1.93	2.78	1.85	4.08	3.58	4.45	20.05	1.95	1.95	2.40	2.53	2.52	3.48	10.93	42.51

Battery C, 62nd Coast Artillery (Antiaircraft), Firing 3-inch A. A. Gun, Model 1918.

TABLE IV.

Battery E, 62nd Coast Artillery

	30-CALIBER MACHINE GUNS																						
	PRELIMINARY																						
	Day																		Night				
	May 18 to May 21	May 22	May 26	May 29	June 2	June 4	July 14	July 14	July 16	July 16	July 30	August 3	August 14	August 25	September 1	Total	June 23	July 8	Total	June 8	June 18	June 19
Total shots fired	46770															89994						
Shots fired at moving targets		3795	2850	1315	5760	2000	3390	3595	1305	1572	4025	4030	230	7597	1760	43224	4500	1500	6000	3845	3850	38
Hits on actual moving target		12	6	21	26	?	4	18	20	5	0	8	4	16	4	144	?	0	0	?	8	
Targets shot down by gun fire		0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
Targets lost for any cause		0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	
Hits on hypothetical target		13.2	6.6	23.1	28.6		6.	27.	30.	7.5	0	12	8	27.2	6.	195.2		0	0		12	19
Per cent of hits		.34	.20	1.70	.49		.18	.75	2.29	.48	0	.297	3.47	.357	.341	.4735		0	0		.312	.5
Hits per battery per min.		8.8	6.6	52.0	14.2		4.6	22.0	55.5	13.4	0	8.39	44.4	7.35	8.	12.108		0	0		8.16	14.0
Hits per gun per min.		1.1	.82	6.5	1.8		.58	2.7	6.6	1.7	0	1.05	5.55	.92	1	1.5135		0	0		1.02	1.7
Hits per thou. rounds (actual)		3.16	2.21	15.9	4.5		1.18	5.0	15.3	3.19	0	1.98	17.4	2.11	2.28	3.49		0	0		2.08	3.3
Hits per thou. rounds (theoretical)		3.48	2.52	17.5	4.9		1.77	7.5	23.0	4.79	0	2.97	34.7	3.57	3.41	4.735		0	0		3.12	5.0
Rounds fired per battery per min.		2528	2850	3168	2808		2640	2844	2426	2800	2702	2820	1276	2052	2350	2557		3125	3125		2620	278
Rounds fired per gun per min.		316	356	396	351		330	355	303	350	338	352	159	256	281	319.6		391	391		334	34
Slant range feet (average)		1740	1610	1230	2320		2960	3460	3150	3150	3492	4380	1350	3315	3558	2901		2890	2890		3490	309
Horizontal range feet (average)		1500	1450	1200	2200		2814	3187	2700	2700	3165	3545	1000	2950	3240	2434		2550	2550		3300	270
Altitude feet (average)		900	700	400	685		1675	1940	1600	1600	1542	1930	750	1435	1226	1260		1350	1350		1400	130
Average ground speed of plane							76.	76.5	75	75	75	72	75	71	72	74.16						
Actual firing time, minutes		1.50	1.00	0.41	2.02		1.28	1.26	0.54	0.56	1.49	1.43	.18	3.70	.75	16.12		.48	.48		1.45	1.0

between the months of May and August fired approximately 4,000 rounds of 3-inch shrapnel, 215,833 rounds of caliber .30 and 75,449 rounds of caliber .50 ammunition at sleeve targets towed by airplanes. These practices were held for the purpose of training personnel, testing the matériel, and recording the number of hits on an hypothetical target, and the number of shrapnel holes in the sleeve target. For these tests Martin bombers flew at heights and ranges unknown to the firing batteries, towing cloth sleeve targets in the form of a truncated cone 5 feet in diameter at the front, 3½ feet in diameter at the rear, and 15 to 20 feet long. A small steel wire 2,100 feet long was used for towing the target, and the drag of the sleeve and the wire reduced the speed of the towing plane, so that this speed varied between 50 and 70 miles per hour, depending upon the velocity and direction of the wind. The bombers flew straight courses at approximately constant but unknown altitudes. Shrapnel was used in these tests, as it was considered unsafe to use high explosive shell.

In order to judge the results, an observer rode in the plane with an instrument to record the location of the bursts over or short, and above or below the target; and another observer on the ground measured with an instrument and recorded the position of the bursts to the right or left of the target. By plotting the records obtained by both observers, the number of hits was recorded.

The War Department, as a result of certain tests (McNair Board Report) prescribed that a hit would be recorded if the shrapnel burst 50 yards above or below the target; 35 yards short of or 15 yards past the target; and 50 yards to the right or left, as measured from the ground. The number of holes found in the sleeve targets were also recorded. These data are given in Tables II and III.

It should be understood in this connection that the object to be accomplished by the tests at Fort Tilden was training for the antiaircraft artillery units and testing of the efficiency of the matériel. As has been stated, shrapnel was used instead of the standard antiaircraft shell, which is a high explosive shell, while the target was a sleeve, which was of necessity much smaller in dimensions than a bomber. It was necessary, therefore, to judge the skill of the personnel and the efficiency of the matériel by transforming the results obtained as nearly correctly as possible into results that would have been obtained if the standard ammunition could have been used and the target had been a bomber instead of a sleeve. Furthermore, the target could not be examined each time immediately after being towed in front of the guns, so that, unless the burst of each shot was observed, the effect of each series of firings could not be ascertained.

These tests indicate that on an average of 4.6 per cent rounds of 3-inch ammunition fired under similar conditions may be expected to burst within the prescribed limits. Towards the end of the season; that is, during the months of July and August, an average of 5.2 per cent hits was being obtained. All these firings were conducted with

IV.
Artillery Antiaircraft.

30-CALIBER MACHINE GUNS																		50-CALIBER MACHINE GUNS												
RECORD												TEST						PRELIMINARY						RECORD				TEST			
Day								Night				Day	Ngt.	Ngt.	Day			Day						Day				Day			
June 5	June 18	June 19	July 20	July 23	July 28	August 6	Total	June 24	June 30	July 2	Total	June 10	July 13	July 13	August 17	Total	Total	August 27	September 1	September 3	September 8	September 9	Total	September 10	September 14	September 15	Total	September 17	September 17	Total	Total
																	159162														31241
945	3850	3870	3960	4130	3820	4133	27608	3817	4140	8525	16482	2448	4465	4235	7930	19078	112392	1496	2135	2640	2390	1685	10346	4390	3600	3515	11505	4015	5375	9390	31241
7	8	13	6	10	8	16	61	10	7	12	29	17	8	13	20	58	292	0	0	7	0	0	7	2	5	22	29	?	5	5	41
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1	1	0	1	3
1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1	1	0	0	0	0	1	0	1	2
	12	19.5	9	15	12	24	91.5	15	10.5	18	43.5	14.45	12	19.5	30	75.95	406.15	0	0	15.5	0		15.5	4	9.1	33	46.1	0	7.5	7.5	69.1
	.312	.504	.228	.363	.313	.581	.385	.393	.253	.211	.264	.593	.29	.46	.377	.398	.382	0	0	.587	0		.179	.092	.256	.939	.4007	0	.14	.0795	.231
	8.16	14.08	6.88	10.7	8.16	18.8	11.48	11.28	7.36	5.2	7.26	23.8	8.37	14.81	12.82	12.93	11.14	0	0	8.29	0		1.836	1.09	2.71	12.32	4.752	0	2.16	1.277	2.739
	1.02	1.76	.86	1.34	1.02	2.35	1.435	1.41	.92	.65	.908	2.98	1.04	1.85	1.60	1.615	1.393	0	0	1.04	0		2.29	.136	.34	1.54	.594	0	.27	.1596	.3424
	2.08	3.35	1.52	2.42	2.09	3.87	2.367	2.62	1.69	1.41	1.76	6.95	1.79	3.07	2.52	3.04	2.745	0	0	2.65	0		.808	.45	1.39	6.25	2.52	0	.93	.5324	1.312
	3.12	5.04	2.28	3.63	3.13	5.81	3.850	3.93	2.53	2.11	2.64	5.93	2.9	4.6	3.77	3.981	3.82	0	0	5.87	0		1.79	.92	2.36	9.39	4.007	0	1.4	.798	2.213
	2620	2782	3025	2951	2596	3220	2994	3000	2892	2650	2751	3120	3120	3200	3380	3250	2924	860	803	1412	1101	1402	1072	1194	1067	1322	1186	1690	1580	1600	1239
	334	318	378	369	324	402	373	375	361	331	344	377	390	400	422	406	365.5	108	100	178	130	175	134	149	133	165	1452	211	197	200	155
	3490	3090	3220	3498	3420	2700	3236	3860	3300	2985	3382	3680	2727	3147	3000	3138	3109	2950	3558	2877	3300	3072	3271	3558	3492	3729	3593	3909	4020	3964	3506
	3300	2700	2500	3000	2700	2190	2731	3300	2700	2751	2917	3525	2365	2580	2466	2734	2673	2410	3240	2313	2796	3304	2812	2679	2525	3150	2784	2813	3416	3115	2865
	1400	1300	2000	1800	2100	1620	1703	2000	1900	1750	1883	1170	1275	1690	1535	1415	1442	1640	1226	1552	1592	1752	1560	2048	2112	1350	1837	2272	1875	2073	1746
			77.5	72	76	76	75.4								73.4	73.4	74.2	74	72	73	72.4	72.5	72.8	73	79.9	73.8	75.5	75	74	74.5	74.3
	1.45	1.06	1.31	1.40	1.47	1.28	7.97	1.33	1.43	3.23	5.99	.78	1.43	1.32	2.34	5.27	36.43	1.74	2.66	1.87	2.17	1.21	9.65	3.67	3.37	2.06	9.70	2.40	3.47	5.97	25.32

the 3-inch antiaircraft gun, Model of 1918, which was built during the war. The ammunition, fuzes and fire-control instruments (except the height finders), which were used in these tests were also of war time manufacture. The altitudes at which firings were held did not exceed 6,000 feet, as the small sleeve target could not be seen by the gunners beyond this altitude.

Similar records were obtained with caliber .30 and caliber .50 machine guns firing at low flying targets. These are given in Table IV. In the case of the machine guns only actual holes in the targets were recorded. These records show that the number of actual hits on the sleeve target was 2.47 per 1,000 rounds of caliber .30 and 1.16 hits per 1,000 rounds of caliber .50, at mean ranges of 3,052 feet for caliber .30 and 3,522 feet for caliber .50 guns.

Firings at Aberdeen Proving Ground.

In order to determine the pattern produced by the 3-inch antiaircraft high explosive shell, panel tests have been held recently at the Aberdeen Proving Ground. These tests were conducted by firing the shell against bursting screens and catching the fragments on vertical wooden walls placed at different distances from the point of burst. It is found from these firings that the pattern of the burst of a high explosive shell is irregular, and it is therefore somewhat difficult to formulate simple rules as to the relative position of airplane and burst at which shell fragments would hit the plane.

In computing the size of the danger space caused by the bursting of the shell, the dimensions of the target were, of course, taken into consideration. For instance, the modern bombing plane has a wing spread of approximately 74 feet, a length of about 42 feet, and a height of 14½ feet. It was considered, in computing the size of the new hypothetical target based on tests at the Aberdeen Proving Ground, that the plane would be hit if any portion of it were found within the danger space of the shell. The hypothetical target for the 3-inch gun was therefore determined to be of the following shape and dimensions: A cylinder extending 150 yards short of the target, 25 feet in diameter, in a plinth 22 yards in height and 50 yards in radius. This takes into consideration approximately the average surface of the bomber that would be exposed to shell fragments, this surface varying with the course of the bomber relative to the position of the gun.

The experiments just referred to indicate that the shell fragments produced with the ordinary design of antiaircraft shell are not sufficiently uniform in size, some being too large, and a great many being too small. It is possible to regulate the size of these fragments by heat treatment of the shell and by the design of the shell, so as to make them much more nearly uniform. It is possible, also, that better distribution of shell fragments can be obtained. At any rate, it may be confidently stated that the efficiency of high explosive shell fire against airplanes can be increased by better control of the fragmentation of the shell.

Discussion of Results Obtained at Fort Tilden.

From tests made at the Aberdeen Proving Ground with the types of gun and ammunition used at Fort Tilden, the probabilities of hitting the hypothetical target actually used at Fort Tilden and the one later decided upon as a result of these tests are shown for various times of flight in the following table:

Time of Flight, Seconds.	Probability of Hitting — Per Cent. Old Hypothetical Target.	New Hypothetical Target.
6	43	86
8	37	72
10	32	55
12	29	45
14	26	35
16	22	26
18	20	19
20	17	15

This table shows the probabilities of hitting the target on the assumption that the gun is correctly pointed, no errors having been made by the instruments or personnel in determining the future position of the target, or in laying the gun, so that the projectile would reach the future position of the target at the same time the target does. These results were obtained by most careful firings at the proving ground and by locating the bursts by special measuring instruments. From the data so obtained the probabilities were computed by the ordinary mathematical methods.

It will be noted that the probabilities of hitting either target decrease quite rapidly as the time of flight increases. About one-half of this decrease in accuracy is due to the decrease in accuracy of the powder train fuze. There is every reason to hope that the new mechanical fuzes which we have under development will materially improve the accuracy of antiaircraft shooting when the time of flight is greater than 12 seconds. This accuracy of gun and ammunition will also be improved by the adoption of a non-hygroscopic powder which will not have its power varied irregularly by irregular absorption of moisture in storage and on the battlefields. Such powder is now under development. The new flashless powder, while not affecting the accuracy of fire when the new computing instrument referred to later is used, will aid the antiaircraft defense materially as the position of the guns will not be disclosed when firing at night. By careful selection of shell as to dimensions and weights and grouping them in lots so that the shells of each lot will vary as little in dimension and weight as possible, greater accuracy of gun and ammunition should be secured. A project to this end has now been inaugurated. Our new models of antiaircraft guns will have a muzzle velocity 400 feet per second greater than that of the guns used at Fort Tilden, and our latest models of antiaircraft shell will by their stream-line form encounter much less air resistance than the shrapnel used at Fort Tilden. Both of these factors will increase the accuracy of antiaircraft fire by decreasing the time of flight for a given range. It is fair to assume that the theoretical accuracy of gun and ammunition as shown in this table can be very materially increased.

The most illuminating conclusion that can be drawn from a consideration of the theoretical probabilities of hitting the airplane, on the assumption that the gun is correctly pointed, results from a comparison of these probabilities with the hits in the practice at Fort Tilden. The average time of flight at Fort Tilden was about 10 seconds and from the table above it appears that the number of hits on the hypothetical target actually used should have been, if the gun were correctly laid, 32 per cent, or using the new hypothetical target determined at Aberdeen, this figure should have been 55 per cent. Actually the percentage of hypothetical hits for the whole practice was about 4.6 per cent. Here is a tremendous discrepancy between the percentage of hits actually obtained and the percentage that should have been obtained if the guns had been correctly pointed at all times; and it leaves a tremendous field for improvement in accuracy of antiaircraft fire, using the same guns and ammunition as were used at Fort Tilden.

It is the function of the personnel and the fire-control instruments which they use in antiaircraft practice to put the center of impact in the right place, and it is fair to assume that a large part of the correctable error may be charged to the fire-control instruments used. How great this error is cannot now be stated, but the present instruments are being tested at the proving ground and their degree of accuracy when used against an actual airplane target will be obtained by means of the camera obscura installation. It may be said in this connection, however, that the principal errors should be found in the R. A. corrector of French war-time design which, with the height finder, constitute the basic instruments for determining the future position of the plane.

Among the most important defects of the R. A. computer are the following: It computes the requisite data only approximately; it does this intermittently, once in 8 seconds, for the position of the plane after an interval of 8 seconds plus the time of flight of the projectile. It does not compute the actual elevation of the gun to hit the plane in its future position, but only the angle to be added to that given by a cannoneer at the gun by pointing his telescopic sight at the plane. Similarly the R. A. instrument does not compute the actual angle of azimuth at which the gun must be set to hit the plane in its future position, but only the angle of azimuth at the gun described by the plane during the time of flight of the projectile, making it necessary for another cannoneer with a second telescopic sight on the gun to keep the gun continually pointed at the plane. Moreover the gun should be fired exactly 8 seconds after the R. A. computer furnishes the data, since this instrument is constructed on the assumption that it will take just 8 seconds to load, aim and fire the gun after the firing data is communicated to the firing squad.

A new and improved data computing instrument is designed along more scientific lines than the R. A. corrector. The data computed by it is exact. Moreover, the data does not have to be telephoned to cannoneers at the gun to be set off on sights and other instruments. By an electrical transmission system the computing instrument itself moves azimuth and elevation pointers on the gun carriage and keeps these pointers continuously set to indicate how the gun should be elevated and traversed

to hit the plane. No sights on the gun are required and the cannoneers at the gun have only to elevate and traverse the gun until other pointers actuated by these movements match the pointers controlled by the computing instrument. The personal errors of the two men at the two sights on the gun are therefore entirely eliminated in the new system and a material increase in accuracy of fire should result therefrom. A pointer on the fuze setter will also be kept continuously set by electrical transmission from the computing instrument while another cannoneer will keep the fuze setter continuously set by turning a crank thereon to match the fuze setter pointer with that controlled by the computing instrument.

This new instrument practically does away with all personal errors at the gun except those very slight errors which may occur in the comparatively simple act of matching pointers, and, moreover, the gun is continuously pointed according to the data determined and can be fired as soon and as often as it can be loaded. With this system, too, the computing instrument has only to predict the future position of the target over a time interval equal to the time of flight.

There is also under development a relatively simple and promising device which will do away with the necessity of manually elevating and traversing the gun and turning the fuze setter to match pointers. By this device —an electrical and mechanical combination—the gun will be pointed and the fuze setter kept set by the computing instrument, so that all the cannoneers at the gun will have to do is to insert the cartridge in the fuze-setter, withdraw it and load it into the gun.

We can then say we are on the eve of removing all the personal errors that occur at the gun and there remain only the personal errors of the men operating the computing instrument, the height finder, and the wind computer, as well as the errors, if any, inherent in the instruments.

The height finder is an instrument constructed on correct scientific principles. The one used at Fort Tilden has a 3-meter base. Its accuracy depends on the training and skill of the operator, but this accuracy for a given operator will increase directly as the length of the self-contained base. If the height finder is responsible for an appreciable part of the inaccuracy of antiaircraft fire, one with a larger base can be obtained. The only limit to the length of base is the mobility of the height finder and its means of transport. So long as this is not less than that of the 3-inch gun and carriage, it will not be objectionable.

The following table gives the probable errors of a skilled man, using height finders of varying lengths of base in determining varying altitudes at a horizontal range of 5,000 yards.

ALTITUDE YARDS	LENGTH OF BASE IN FEET		
	9 feet	12 feet	18 feet
	Approximate error of reading in yards		
1000	4.7	3.5	2.4
3000	18.	13.	9.
5000	34.	26.	17.

It is not considered that the instrumental errors of the wind computer are serious, though there is undoubtedly a possibility of improvement of the instrument.

The method of correcting for the "conditions" of the day is taken from the French. The accuracy of this method is now being investigated and it is not unlikely that improvements therein may be made.

Finally, accuracy will of course improve with continued training of personnel; and it should be remembered that until the last two years, the antiaircraft artillerists have had no target to shoot at. Imagine for example the difficulty of developing expert infantry riflemen if there were no targets available for them to shoot at during their training.

So far as day firing is concerned, therefore, there is every reason to expect a large increase in the accuracy of antiaircraft fire with the improvements in matériel contemplated and with continued training of personnel. We should also bear in mind that during the day enemy bombers will not operate singly against ground targets if we have any pursuit planes available to attack them. Instead they will fly over their objectives in formations which cannot dive, turn or zig-zag as a single plane may do, and they will present a large and distinct target to the defending antiaircraft guns.

Night Firing

The accuracy of the night firing at Fort Tilden was on the whole greater than that of the day firing, and I think it can be stated that a plane illuminated at night by a searchlight is no more difficult to hit with antiaircraft guns than the same plane in daylight. To illuminate hostile planes with searchlights it is necessary first to locate them. At present this is done with sound apparatus, ordinarily called "listening devices." While these devices are in an early stage of development, very gratifying results were obtained with them last summer at Camp Dix. When four listening devices and four searchlights were used there was no failure to put the searchlight on a plane towards the end of the season's practice. The maximum range of our present listening device is approximately 12,000 yards. That of our present searchlight having six hundred million candle power is from 6,000 to 15,000 yards, depending on atmospheric conditions. A new searchlight has recently been developed under the direction of the Corps of Engineers which has one billion candle power.

The development of listening and other devices for the purpose of locating airplanes when they cannot be seen is still in its infancy but promising experimentation along these lines is being carried on in this country and abroad. All listening devices so far used depend upon the human ear to receive the sound waves gathered by the horns of the instrument. A most promising development of listening devices, however, contemplates the substitution of electrical detectors for the human ear. It is hoped and expected that this improvement may lead to great increases in the accuracy and range of the devices, even to the point where searchlights may be dispensed with and guns accurately pointed with the data furnished by the listening devices alone. A prominent European designer of antiaircraft fire control instruments told me last summer that he had great hopes of the development of such an improved listening device within a year.

It is interesting to note that the improved computing instrument previously referred to is well adapted to the computation of firing data for antiaircraft guns in connection with this proposed improved listening device, when for any reason the plane cannot be seen from the computing instrument. In this case the operators at the instrument would follow the movement of pointers actuated by the listening device instead of following by means of telescopes the movement of the plane.

Machine Gun Firing

The results obtained with machine guns at Fort Tilden last summer are far below what might be expected if only the inherent accuracy of gun (not including the mount) and ammunition is considered. A long series of firings by the Ordnance Department with machine guns shows that with the regular Infantry mount and with the guns clamped to prevent vibration, practically all projectiles should hit a vertical target 8 yards high by 6 yards wide at a range of 1,000 yards, and that about 25 per cent of the projectiles should hit a vertical target one yard high by three-fourths of a yard wide at the same range.

If the machine gun is held like a cannon rigidly in its mount the cross-section of the sheaf of projectiles, that is, what corresponds to the pattern in the shotgun, is really too small for effective fire against airplanes as near as 1,500 yards or less from the guns, unless taken care of as indicated later. On the other hand, the mounts used at Fort Tilden, with the guns free for pointing and steadying with the shoulder of the gunner, permitted the guns to vibrate in all directions to such an extent as to cause excessive dispersion of the projectiles.

The obvious remedy is first to provide more substantial mounts of the pedestal type with elevating and traversing gearing. It appears now that each mount should carry at least four guns of .30 caliber and as many as possible of .50 caliber. All guns carried by one mount would be synchronized to fire in unison by one trigger and each mount would be transported by and fired from a truck or trailer. But with these guns so mounted the pattern of each gun will be too small. This can be remedied by adjusting the guns of one mount so that their combined pattern will be about four times or more larger than that of one gun. Deflections can be set off from one mount to another in a battery so that what may be called the pattern of the battery will be of substantial size, approximating or perhaps exceeding the danger area surrounding a bursting 3-inch high explosive shell.

It is quite possible mechanically to provide a machine gun battery pattern of this kind and when this is done with the improved mounts under consideration we may expect a decided improvement over the results obtained at Fort Tilden with machine guns.

With improved machine gun mounts and with a reasonable pattern, we must then improve our facilities for placing and holding this pattern on the plane. These improved facilities will include a telescopic sight of large field and low power, an improved range finder and an improved speed indicator.

At very short ranges the gearing of these mounts may have to be released and the gun made free from following the rapid movements of the plane by pointing with a shoulder rest. In this case the fire will be controlled by directing at the plane the trajectory which will be brightly outlined by tracer bullets.

For use in certain positions where the terrain or other conditions may make it desirable, simple tripod mounts should be provided. These are light and may be carried as additional equipment on the trucks or trailers of the pedestal mounts. Extra guns for the tripod mounts will not be required as when they are used the guns may be transferred to them from the pedestal mounts. If preferred extra guns for the tripod mounts can be provided.

37-mm. Gun

The 37-mm. antiaircraft gun is only now under development. The method of fire control with this gun will be similar to that used with antiaircraft cannon of larger calibers. As the projectile of this gun is fuzed to burst only on impact with the plane, it is not improbable that it will be found advisable to design a mount that will carry several guns and to arrange for a reasonable pattern at the target as proposed for machine guns.

Conclusions

In conclusion, I am convinced that with provision for liberal training and for continued development of matériel along lines already well established, the effectiveness of antiaircraft fire will increase so that the combat between planes and guns on the ground will by no means be an unequal one. I believe that the losses of planes, that may attempt during the day to bomb objectives protected by improved antiaircraft guns and machine guns, will be so great that the commander will hesitate to order such bombing unless the object to be obtained is so vital that he can afford to suffer a great loss of planes in the operation. Even at night the combat between planes and antiaircraft guns will not be an unequal one. To be sure the planes will probably attack singly and they will be in a measure protected by darkness, but this will also add to the difficulties of their mission, and they will always run great risk of being located by the improved listening devices and searchlights that undoubtedly will be developed for that purpose.

In stating my belief as to the efficacy, present and future, of antiaircraft guns, I do not want to give the impression that I do not appreciate the powerful offensive properties of the airplane. The airplane is a wonderful weapon for offense and for defense, particularly against attack from the sea. Its possibilities are enormous and we should aim to develop these possibilities to the fullest extent. We should have an air force at least equal to any that may be brought against us from over seas. But the very power of the airplane in offense emphasizes the need for an antiaircraft gun defense.

The Ordnance Department of the Army is charged with the design, procurement, supply and maintenance of the weapons and ammunition used by the Air Service and also the weapons and ammunition used by the antiaircraft defense. It must develop the most efficient armament for both services and be prepared to supply this armament in the amounts and at the times and places required. From the nature of its functions it must see both sides of the question.

As an Ordnance officer, I am impressed with the necessity of developing both services to the maximum extent permitted by appropriations, in accordance with the defense plans of the General Staff. Both services are new and of outstanding importance. In my opinion they present the most pressing technical problems which the War Department must solve at the present time.

The Industrial Engineer in National Defense

By

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A BRIEF explanation of Industrial Mobilization should carry the conviction that its problems afford opportunities for industrialists to apply engineering talents in the broadest economic sense and engineering talents of the highest order.

Until the World War military preparation was confined almost exclusively to the realm of tactics and strategy. "Men! More Men!" was the cry of nations in the throes of war. Supplies and equipment took care of themselves. To the victor belonged the spoils. Conquering armies lived off vanquished nations. The equipment of the soldier was simple, his requirements few. "An Army marched on its stomach." Clothed and fed soldiers under superior commanders were prepared for the worst. A million men might be called to arms as quickly as they could raise their right hands.

Just preceding the World War, however, there loomed from the immediate past millions of tons of steel available for guns and ammunition, millions of tons of chemicals available for powder, gas, and explosives, and millions of automobiles representing a potential industry for airplanes, tanks, and tractors. Science, invention, and industry had an unprecedented era of progress. Man had achieved far more than the strangest dreams of fiction in his explorations of leagues under the sea and through the air. More steel, more chemicals and more automobiles have been produced since 1910 than in all preceding time. Thus the powers of science, invention, industry and the resources of nations which had developed in leaps and bounds were at hand to be applied to the art of war. It was not surprising then that during the World War more artillery ammunition was expended in fifteen days by the Allies than by the entire Union army during our Civil War.

Nor was it surprising to find America unprepared. It is not necessary to recall to the readers of ARMY ORDNANCE the conspicuous cases of overbuying and competition in the market by supply branches, the inflation of prices, the chaotic and conflicting demands upon facilities which were booked with orders months and years ahead of their capacity, the inability of essential manufacturers to obtain an adequate supply of power, labor or transportation. Vivid examples come to mind at the mere mention of the confusion which existed in American industry at our entrance in the World War. American industry was just gaining its stride at the time of the Armistice, after eighteen months of our participation in the conflict.

Not until after we had passed through the World War did we fully appreciate or profit by these lessons. In January, 1918, the power, transportation and industrial systems of the United States were so close to the verge of collapse as to threaten the effective military operations of the American Expeditionary Forces. How well the best business brains of the country finally organized behind General Pershing's fighting forces to insure a continuous flow of supplies is a matter of personal knowledge and experience with many readers. Supplying a modern army is a civilian, an industrial problem, affecting the entire populace. So also, the economy in time, money, materials and lives which is possible by adequate planning for what amounts to the largest business undertaking in the world—mobilizing American resources for National Defense—is well recognized by industrial engineers. The high economic value of such planning is translated by them into terms of substantial factors of safety which guard against waste and failure in guaranteeing a short successful war.

The correction wisely applied by Congress in order that the nation might profit by these lessons is contained in section 5-a of the National Defense Act which places the munition problem under a civilian, the Assistant Secretary of War. His task is to plan so that every resource, science, profession, industry and every business man and every laborer may be prepared most effectively to meet the demands of National Defense. This is management engineering on a supreme scale.

Plans for substituting cooperation for competition, for synchronizing the program of raising men and munitions can be developed only by the heartiest cooperation on the part of industry, our District Chiefs, the chiefs of the seven Supply Branches of the Army, and on the part of the Navy.

In the last analysis those plans are not the plans of the War Department or the Navy Department or the plans of "Big Business" or any special group, but they are in essence the plans of all the people by all the people to provide for the common defense of the Nation. I am, therefore, not speaking for any individual or group of individuals but rather trying to interpret the spirit of democracy which gives these plans their enduring life, the spirit of America.

Reduced to its simplest terms the task involves solving the equation, Resources = Requirements (in the Quantity, at the Time and in the Place desired). Where resources are not equal to requirements the equation has to be balanced by substitution, conservation, curtailment, priorities, allocations in part or other suitable measures which are most appropriate for the particular item or commodity. To transgress on mathematical usage in order better to convey my meaning, we are not always dealing with exact values or abstract figures. We may in many cases have to proceed by a process of trial and error, by the theory of limits or by a process of bracketing in order

War Department Procurement Districts

W. D. District No.	War Department District Headquarters.	Supply Branches: Quartermaster Corps	Ordnance Department	Air Service	Corps of Engineers	Medical Department	Signal Corps	Chemical Warfare Service.
1	Boston	●	●	○	○	●	○	●
2	Bridgeport	○	● Springfield, Mass.**	○	○	○	○	○
3	New York	●	●	●	●	●	●	●
4	Buffalo	○	● Watervliet, N.Y.**	●	○	○	○	○
5	Philadelphia	●	●	○	●	●	○	●
6	Pittsburgh	○	●	○	○	○	○	●
7	Baltimore	● Camp Holabird, Md.**	●	○	●	○	○	○
8	Cleveland	○	●	● Dayton**	○		○	○
9	Cincinnati	● Jeffersonville**	●	○	○	○	○	○
10	Birmingham	● New Orleans**	●	○	●	● Atlanta**	○	○
11	Detroit	○	●	●	○	○	○	○
12	Chicago	●	●	●	●	○	●	●
13	St. Louis	●	●	○	○	●	○	○
14	San Francisco	●	●	●	●	●	●	●
Total Number of Districts.	14	9	14	6	6	7	3	5

KEY:

● W.D. Districts included in Supply Branch Districts.

Headquarters of Supply Branch District ●

● W.D. Districts included in Supply Branch Districts.

** Peace-time organization.

Chart Showing Procurement Headquarters of the Several Supply Branches.

to attain a most desirable balance. We must introduce reasonable factors of safety.

As an initial step in this work an organization had to be developed. The office of the Assistant Secretary of War is set-up so that it can handle expeditiously any of the various problems in supervising, coordinating and directing this vast work. This organization in brief provides for a Director of Procurement who is the immediate advisor of the Assistant Secretary of War in all matters relating to the supervision of procurement. The Planning Branch is in charge of an Executive Assistant who has as his principal subordinates officers in charge of the Administrative, Commodities, Procurement Control and Industrial Divisions. Among the main sections of the Administrative Division are the Training and the Progress and Requirements sections. The Commodities Division coordinates the work of fifty-four commodity committees of which eighteen are now active. The Procurement Control Division is concerned with such matters as the determination of priorities of facilities and orders, priorities in power, labor, transportation and materials, the allocation of factories, plants and raw materials and studies involving price control, while the Industrial Division has sections relating to Power, Labor, Transportation, Communications, Conservation and Fuel.

The Supervision of the Office of Assistant Secretary of War is exercised over the seven supply branches of the Army: Quartermaster, Ordnance, Engineers, Air Service,

Signal, Medical and Chemical Warfare. These supply branches in turn are charged with responsibility for procurement of commodities peculiar to the work on which each supply branch specializes. For example, the Ordnance Department furnishes, among other items, guns and ammunition, the Quartermaster, food and clothing, and the Engineers, electrical and power equipment. More will be given of these duties later in connection with a review of the opportunities for industrial engineers to fit into these organizations. The necessity for breaking down this tremendous task into seven major branches is apparent. Our war experience has demonstrated, moreover, the equal necessity for apportioning the tasks of each branch among District Chiefs throughout the country. Accordingly the United States is divided along industrial lines into fourteen War Department Procurement Districts with district chiefs representing the Chiefs of Supply Branches in each District. The chart on page 356 shows the headquarters of the various Supply Branches. Our plans therefore contemplate the purchase, inspection and acceptance of supplies under District Chiefs, control being exercised in Washington.

Having defined broadly the task, the organization and the general plan, let us refer again to our original equation and fill in a few details. The first member, Requirements, is based upon a general mobilization plan drawn up by the War Department General Staff. This consists of some 35,000 individual items and 700,000 component parts. As a concrete example, take the service shoe. If the cut soles of the shoes required for six field armies were placed in a pile one on top of the other, a stack of soles 375 miles high would result, more than fifty-eight times higher than Mount Everest, the highest mountain peak in the world. 3,570,000 cow hides, 6,000,000 steer hides and 357,000 sheep skins are needed in the nature of raw materials. Shoe factories engaged on this production would need 13,000 primary horsepower, 38,000 laborers per day and over 400 freight cars per month.

The second member of this equation, Resources, has been analyzed by surveys in the districts. In the case of the shoe the greatest number or about 11,500,000 will come from the Boston District; 7,000,000 from the St. Louis District; 5,300,000 from the New York District; and so on through the list of 35,000,000 pairs required. The facilities which are to produce these shoes have in large part been inspected by the District Chiefs and have been allocated by the office of the Assistant Secretary of War, that is, assigned for this particular use by the Quartermaster Department in the event of war. Thus, in the case of the service shoe we believe that we can solve the equation satisfactorily. This will necessitate, however, the utilization of a commercial shoe substitute for the first three months, the use of a substitute for the present tanning materials, and rigid conservation in our leather supply from the very outset of an emergency. Our solution involves an equitable distribution of the load with respect to capacity and field service of shoe facilities, calls for less than fifty per cent diversion of facilities which make men's shoes, and imposes a load on the entire industry (men, women and children's boots and shoes) of probably less than fifteen per cent.

The story of the service shoe which has been told only in broad outline illustrates the details which have to be taken into consideration in the solution of this general equation for one major item. You can well imagine the vast scope of this work in solving this equation for thousands of major items of supply.

There are certain factors entering into our problem which are general to all major items such as power, labor, finance, contracts and transportation while others like raw materials are common to a group of commodities. Their ramifications have to be traced within reasonable limits throughout the entire procurement program if we are to plan for all essentials. I shall refer briefly to important phases of our plans covering these general subjects.

The subject of the utilization of labor in war is one which is being intensively studied in the Office of the Assistant Secretary of War with a view to benefiting by the experience in the World War of ourselves and foreign powers and adapting best principles, practices, and policies to the special economic conditions which may be met in the event of another great emergency. The maximum employment of female labor to substitute in large part for men called to the colors offers great possibilities. Of the 41,000,000 persons gainfully employed in the United States some 6,000,000 are women. The proportion of women can be greatly increased in a major emergency.

Closely related to the subject of labor is the training of personnel. Progress has been attained in this direction in the establishment of the Army Industrial College and instituting arrangements whereby officers are annually detailed to the Harvard School of Business Administration. The college has graduated both Army and Navy officers, some of whom were previous graduates of the Army War College. Its primary purpose is to train Army officers in the useful knowledge pertaining to the supervision of procurement of all military supplies in time of war. The Harvard School considers only peace-time methods of business administration as distinguished from training given in the college. This education will serve to increase the efficiency of procurement agencies materially.

A tentative plan has been drawn up for the control of railway transportation in a major war. The plan, formulated after discussion with officials of the Association of Railway Executives, contemplates that the railways will be taken over in case of absolute necessity by the Secretary of War as provided in the Army Appropriation Act of August, 1916, and general direction and control will be exercised by the Secretary of War. Actual operation and carrying out of general policies will be left largely to existing railway organization. The American Railway Association has appointed an official in each of the fourteen War Department Procurement Districts in order that cooperation may be secured between the Army and the Railroads in solving local transportation problems.

The Corps of Engineers, which has been carrying on a power survey for the past four years, has divided the country into Power Zones. The Zones were made up with the idea of corresponding closely to the fourteen Procurement Districts into which the country has been divided by the War Department. These Power Zones have their headquarters at the present time in certain designated District Engineer Offices which are now collecting data and preparing maps and charts which will be of great value in time of war. These organizations form the field force for the

Supplies Procured By the War Department

Quartermaster Corps	Ordnance Department	Air Service	Signal Corps	Engineer Corps	Medical Department	Chemical Warfare Service
1. Subsistence and Forage	1. Small Arms and Machine Guns	1. Airplanes	1. Wire and Cable	1. General Supplies, exclusive of water supplies	1. Drugs	1. Chemicals, Oragnic and Inorganic Compounds
2. Clothing and Equipage	2. Mobile Artillery	2. Ballons and Airships	2. Radio Material and Equipment	2. Water Supply Equipment	2. Surgical Dressings	2. Toxic Gases
3. Fuel, Oils, Paint and Chemicals	3. Railway and Seacoast Artillery	3. Engines, Aeronautical and Airplane Instruments	3. Batteries, electrical	3. Wood, Steel and Raw Materials	3. Surgical Instruments and Appliances	3. Smoke materials, except for ammunition below caliber of 37-mm. and pyrotechnics
4. Vehicles, Harness and Saddlery	4. Fire Control Instruments	4. Combat and Landing Equipment.	4. Telephone and Telegraph Equipment	4. Machines and Machine Tools	4. Laboratory Apparatus and Supplies	4. Incendiary materials, except for ammunition below caliber of 37-mm. and pyrotechnics
5. Miscellaneous Supplies and Salvage	5. Tanks, Tractors, and Trailers	5. Aerial Photographic Equipment and Supplies	5. Signal construction equipment	5. Railway rolling stock	5. Dental Instruments, Appliances and Supplies	5. Gas defence appliances
6. Machinery and Electrical Equipment	6. Targets and Target Material	6. Gases used in the inflation of balloons and dirigibles. Containers for same	6. Miscellaneous electrical and mechanical equipment	6. Railway Construction and Maintenance of way equipment and supplies	6. X-Ray Apparatus, Appliances and Supplies	6. Containers of all types for bulk shipment of gases
7. Construction Materials	7. Seacoast, Railway and Antiaircraft and Major Caliber Artillery Ammunition	7. Trucks, Truck Bodies and Trailers designed for special Air Service uses	7. Meteorological equipment	7. Surveying and mapping equipment	7. Hospital Furniture and Equipment	7. All other material used exclusively by the Chemical Warfare Service
8. Motor Vehicles	8. Minor and Medium Caliber Ammunition for Mobile Artillery	8. Aviators' special clothing and special personal equipment	8. Photographic equipment and supplies	8. Map reproduction equipment	8. Veterinary Appliances and Veterinary Hospital Supplies	8. Smoke producers and similar C. W. S. devices
9. Marine Equipment	9. Grenades, Pyrotechnics and Aircraft Bombs	9. Special Technical Air Service material (Metals, alloys), Chemicals, Acids, Paints, Woods, Fabrics, Fuels, Glues, Oils, Lubricants and Dopes	9. Pigeon Equipment	9. Electrical Equipment exclusive of Searchlights	9. Field Equipment and Supplies	9. Chemical Engineering Equipment. (In Chemical Warfare Manufacturing Plants)
10. Remounts	10. Machine Gun, Machine Rifle, Automatic Rifle and Small Arms Ammunition	10. Special Equipment, Machinery and Tools, including electrical	10. Communication equipment accessories	10. Searchlight and Seacoast fortification special equipment	10. Chemicals and Reagents	10. Special Chemical Weapons

control of power. They operate under the general administrative direction of the Chief of Engineers in executing the policies and decisions of the Assistant Secretary of War. All questions of allocation of power or priorities for military and naval needs will depend on decisions of the Army and Navy Munitions Board. In the event of war, the results of our planning will be immediately evident. Data as to the productive capacity of the zones and of the requirements of the Army and Navy will be known. Possible shortages will be forestalled by having placed our orders elsewhere. On the other hand, where it is impossible otherwise to distribute the war load, we will be in a position to issue promptly priority orders and curtail unessential uses of power. The present tendency in the installation of large central stations and the interconnection of large systems will, of course, be of greatest importance.

The board of officers engaged in the preparation of war-time contract forms has been at work for over two years. Constructive criticism has been received from business men and manufacturers on proposed forms for purchase orders; short form contract; and the adjustable fixed price contract. Another form is still under preparation—the adjusted compensation contracts for construction and manufactured articles. Probably a year or more will be required before all of these forms receive final approval.

Commodity committees of the Office of the Assistant Secretary of War with members from supply branches which are greatest users of the commodity are studying materials in which shortage is likely to occur in an emergency. Contact is established with industrial leaders, experts in governmental departments, trade associations and technical societies. There are eighteen active and thirty-six inactive committees covering in all 180 commodities. This study is made with the purpose of collecting, collating and evaluating data on requirements (Army, Navy, Civilian) and resources so that procurement control may be exercised in conservation, curtailment, priority and allocations of materials and on limiting requirements in new facilities to a minimum. Requirements of the Navy are ascertained by means of commodity committees of the Army and Navy Munitions Board. Civilian requirements are determined from industry and an analysis of the records of the World War.

A number of committees of Army and Navy officers of the Army and Navy Munitions Board are likewise engaged in agreeing upon joint allocations for survey of facilities to produce the requirements of both services. In this way conflicting demands are adjusted in time of peace and an understanding is reached on eighty-five to ninety per cent of the war load to be placed on industry in the event of an emergency. This arrangement also has the advantage as far as industry is concerned in that both joint and common requirements of the Army and Navy may be presented in the same way and at the same time.

With the explanation which has been given a general understanding should be had of the broad scope of the work and some of the details. I should like to emphasize now the many opportunities for industrial engineers to fit harmoniously into this great machine. Over ninety-five per cent of the officers selected to man these positions in the event of war will be drawn from Reserve Officers and industrialists. Tasks are available in the Office of the Assistant Secretary of War, in the offices of the chiefs of Supply Branches, in District Offices and in the thousands of factories throughout the land.

In round numbers 19,000 facilities have been allocated. Of these 500 are jointly allocated. The greatest number of allocations are in the Chicago district, 2,770, and in the Philadelphia district, 2,200. The state with the largest number of allocations is New York, 2,800. Allocations by supply branches are Quartermaster, 13,000; Corps of Engineers, 2,000; Ordnance, 1,400; Medical, 1,000; Air Service, 750; Signal Corps, 500; Chemical Warfare Service, 350.

I believe a picture of the innumerable opportunities can best be grasped by the engineering mind if I use its own language. Let us visualize a large chart having seven vertical columns in which will be listed commodity classifications of the seven Supply Branches. Selecting ten classifications to include all supplies to be procured by each Department, our chart would appear as is shown on page 358.

Next, our chart would show for each of these ten different commodity groups for each of the seven Supply Branches the engineering tasks which may be projected in horizontal lines through all these commodities. As diversified as is business in the engineering profession, it appears that appropriate work could be found to fit the particular qualifications of each individual. Tasks involving drawing up specifications, organization, experimentation, production, inspection, installation, administration and management, and other missions for engineers specializing on power, raw materials, finance, labor and transportation, to mention only the most important ones, permeate the whole list. With such a chart before our mind's eye we may readily determine our great opportunities for service. The problem of finding tasks for each individual is further simplified by the fact that the commodities themselves serve to localize the particular section of the chart corresponding to the broad commercial classification of engineering work which the industrialist has as a profession such as chemical, electrical, hydraulic, marine, mechanical, mining, railroad, sanitary, steam, and water-supply.

There is one thought which I wish to emphasize in closing. It relates principally to those readers who still retain vivid recollections of our industrial unpreparedness in the past war. I ask you to continue to impart the breath of life into our national plans for industrial preparedness. The day is not far distant when it will be too late to make this appeal. You, who have gained this valuable experience in the World War can now help our younger engineers to fit into their appropriate places in these plans. Create understudies. Give them the advantage of your experience. Preserve the contact. It is not so much a matter of money but brains and service that we need. Accomplishments of American industrialists in the past are a potent harbinger of the high attainments which we may expect with full confidence in the future. May you establish a corps of virile manhood which will carry on from generation to generation and guarantee a continuity in the life of Industrial Preparedness commensurate with the life of the Nation.

Col. Frank A. Scott Addresses Army Industrial College Graduates

COL. FRANK A. SCOTT, Ord. Res., Chief of the Cleveland Ordnance District, organizer and first Chairman of the War Industries Board, 1917, was the principal speaker at the exercises incident to the graduation of the fourth class of officers from the Army Industrial College, Washington, D. C., February 1, 1926.

Hon. Dwight F. Davis, Secretary of War, who founded the College in 1924, presided. Colonel Scott was introduced by Col. H. B. Ferguson, Corps of Engineers, Office of the Assistant Secretary of War. Colonel Scott's address follows:

Col. Frank A. Scott, Ord. Res., Chief, Cleveland Ordnance District.

"You are kind to ask me to appear before you and I enjoy meeting with you. Nevertheless, I feel a degree of diffidence in reciting what took place in 1917, and what I now think about it. We are living in a new world; a world re-created, developed since the war, and it is more familiar to some of you younger men than to us older ones. I was so struck by the force of a comment made by Earl Grey, in his recently published *Memoirs*, that I should like to share it with you:

> 'Control of affairs has already passed in part and must soon pass entirely to younger and fresher minds, who may see further and more clearly, because much that preoccupies us with its strangeness will be to them familiar and intelligible. It is not for us to be confident that, because we know more of the past, we can therefore see more clearly than they into the future. What we can do is to record for them our experience, and our reflections upon it, in the hope that these may provide some suggestion and impetus to thought that in their fresh minds may be fruitful.'

"As a result of the bitter lessons of the War with Spain, we developed the War College and the General Staff. Now, as a result of the lessons of the World War, we are developing the Army Industrial College.

"You are among the early graduates from this new institution. You and those who have recently preceded you have now devoted a part of your lives and dedicated, perhaps, the balance to working out this phase of our national problems.

"When sober-minded men devote a part or all of their lives to a cause, it becomes worth while to examine that cause as to whether such devotion is justified. So, today, between these two classes, let us halt for a few minutes and examine our ground.

"We may safely proceed on the theory that this work is not only worth while, but that it is one of the most valuable and patriotic services which it is possible to render our country at this time. Nationally, we prefer to ignore the subject of war during time of peace, and then we seek scapegoats to carry the blame for national neglect when we have cause for shame. Our last war was no exception to this national weakness. It is futile to try to lay responsibility for unpreparedness on individuals. We know that if a national interest in preparedness had been shown, we should have had it.

"Heretofore I have outlined to you the difficulties and confusion of the early days of 1917; governmental departments exercising separate and uncoordinated authority, competing with one another and our Allies and our civilian industry for everything under heaven; departments trying to develop war strength and yet limited by innumerable peace-time statutes and regulations which were paralyzing in their joint effect on a war effort, and which were not automatically repealed, as they should have been and always hereafter should be by the Act of Congress declaring war.

"The Overman Act was not passed until March, 1918, substantially a year after war was declared, so that coordination, control of prices, priority and many other essential powers had to be exercised by improvised organizations in the meantime, acting by authority of the President.

"Now, as a result of the National Defense Act of 1920, these problems will be lessened, unless we build up another peace-time group of limiting statutes and regulations. As a result of this Act, and through the agency of this College,

we should enter another war with a specially trained procurement staff; with procurement plans and organizations outlined, and with a centralized control to assure proper priority and coordination.

"This Act is one of the most notable steps in the military history of our country. Now, at last, we can be said to have developed a military policy. We have authority of law for a General Staff and a General Staff College; for a Procurement Staff and a Procurement Staff College; and, in the event of war, we should undoubtedly have a super-control acting by authority of the President.

"Whoever undertakes to make procurement plans for major war today must be a fundamentalist. He must go right down to the foundations. Nothing less than the full manpower, material power and spiritual power of a nation will assure victory. To develop this power and bring it to a head on the battlefield within the required time would be sufficiently complicated; but this is not all. Most great wars, except civil wars, have involved allies. To cite only a few modern conflicts—the Wars of the Austrian Secession; the Napoleonic Wars; the Crimean War; the World War. So we may assume that in a great war there would be, in addition to our own, the needs of our allies to be considered.

"Therefore, we can assume that our plans must include—

(a) Supplying our own original requirements and subsequent expenditures;

(b) Supplying at least certain requirements of our Allies; and

(c) Protecting our civilian industry in its natural functions so far as possible and still make the maximum war effort.

"We can assume, also, that even if we have paper programs we will not have the organization to make those programs immediately effective. Therefore, whether we want it or not, there will be a period of improvisation. This period will be shortened and we will emerge into regularly organized effort as a result of the work of this College. Here, then, will be an immense advantage over anything which has preceded it in our history.

"The English-speaking nations have ever, in war, depended more than any other nations on improvisation. It has tided them over, but God only knows at what expense of precious lives, of effort, and of money. Now, in this Army Industrial College we are setting ourselves modestly and patiently to work to save *our* country, at least, from another such sacrifice. As we could not have taken our place in the World War had not the sea routes been guarded by the fleets of another nation; as we could not have mobilized, trained and fought without a General Staff; as we could not have financed the war without the Federal Reserve Bank—so we cannot plan to sustain another war without the aid of an Army Industrial College.

"We must now have a trained Procurement Staff to whom the meaning of Time, Priority and Coordination is synonymous with Life and Death. We might well accept these—Time, Priority, Coordination—as a military trinity, at least for all procurement branches.

"Improvisation as a major dependence in war has had its day, and systematic thinking and planning now take its place. Any student of war must agree with that; and, having proved that, then immediately we have to begin to qualify.

"We are Americans, and we have national characteristics which must be reckoned with. We must not seek to develop a system or an institution that is foreign to the genius of our nation. We are capable of methodical and systematic organization. In many lines of industry we display splendid examples of this organizing power; but we still have much in our national life of the spirit of adventure, the spirit of the old frontiersmen who took life into their own hands and shaped it to their liking; therefore, improvisation is a part of our national genius. Imagination and fresh and unexpected endeavor must be allowed their place and opportunity. Perhaps we could not drill them out if we tried to, but we are too wise to try.

"In our country, the very vastness of its resources in men, material and machinery makes a program of Preparedness difficult. It is almost impossible to make our people understand that military resources are not the same as military strength. Even very intelligent people seem to have difficulty in visualizing the difference between the materials available in peace time and those necessary in war. Money, material, good will, intelligence and patriotic zeal, after war begins, cannot restore to us the precious days, weeks, and months which might have been saved by intelligent planning in quiet times of peace.

"So, along with our endeavor to educate ourselves in this work, must go an effort to educate our people to the necessity for it as a safeguard to our national life and ideals. Not an education in favor of war, but an education in organizing our power and resources so as to make them constitute a safeguard for peace.

"As a nation, we love slogans. Just now, 'No Profiteers and No Slackers' is one of the leading slogans of the American Legion—a noble thought and a popular one.

"We are compelled by every consideration of patriotism and justice to desire to see it made effective in law. Statutes to provide this ideal condition in war would be fundamental. We can not overlook that such statutes, to be effective, must control economic laws which are almost as immutable as the laws of nature and certainly much less well known to us.

"We must recognize the desirability of taking profit out of war and requiring universal service from our citizens, even while we question our immediate ability to assure such ends by statute.

"The war spirit of our people is not automatically aroused by the Act of Congress declaring war; it grows. There is a point at which the country sets itself morally and physically, just as a wrestler does, to receive the shock of the opponent. Then its 'blood is up'; then it is ready for regulation, control and sacrifices.

"I was here and saw this in 1917. I was among those who helped hold the breach while the country was being roused to real effort. It made an inerasable impression on my mind, and I give it to you as something real and not academic. Study it and you will understand why this must be.

"We know so well *now* what our people are capable of doing and are willing to do; it is so evident *now* by what

processes we might most readily have attained results; so many men and women are known to us *now* whose services would have saved time, lives and money if we had employed them earlier. We can calculate *now* what might have been because we experienced it all and are looking back at it. We mis-calculate. We remember only the final effort of our people and we forget the peace-time spirit which only gradually disappeared in 1917. We must not forget that most of our ideas and ideals during peace must be re-adjusted for war. There is a very exact analogy between a man and a nation being roused for physical, mortal conflict.

"The conditions of war in the social, industrial and economic phases of our national life do not obtain immediately upon the declaration of war. They develop gradually as men are withdrawn for military purposes; as materials are directed into military channels; as transportation is absorbed for military services, etc.

"Then Price Control, Priority and regulation of whatever nature assume a natural aspect and our people even welcome them. It is at this juncture that a super-body can begin to act with effect. It is at this juncture that the war powers of the President may be exercised in the broadest manner to prosecute the war, not only without wakening resentment but with the hearty approval of our people.

"It is at this juncture that Price Control may be enforced without authority other than as given by the President, for American industry has proved that in war it is ready to police itself. This spirit is better than statutes, and statutes are not self-enforcing, even in war time. We do not want to fight one another, but the enemy.

"Doubtless we must have a super-control of all our resources in time of war. One would be inclined to doubt the desirability of appointing this body and endeavoring to organize it, and plan and develop its functions in time of peace. Whether it should be a War Industries Board, or some other super-body, should be determined by the conditions. Its personnel should likewise fit the then conditions. This much is certain: Its authority will arise from exercising the war powers of the President—a vast, undefined and almost unlimited reservoir of power exercised only under war conditions. It is impossible to define these war powers, and it would certainly be dangerous to place any peace-time limitation upon them.

"Thus far in our brief study this morning, we have considered only the advantages of Preparedness; of peace-time programs and skeleton organizations. We should not, in justice to our own belief in Preparedness, ignore the possible arguments against it. Of course, we ignore the foundationless charge that it tends to create a war spirit. There are other and more substantial arguments.

"A trained staff tends to develop traditions and a technique difficult to jettison when they do not fit the need. Preconceived plans, worked out in peace time, may become obsolete and the obsolescence remain unrecognized until the emergency arises, and then we will develop contentions and lose time. Shall we adhere to our plan, or shall we alter it? Peace-time plans will necessarily contemplate the use of many peace-time methods and much peace-time machinery, and these could be, and would be, vastly improved under the stress of war. A poorly laid out plan, or an unbalanced piece of organization machinery may prove more of an obstacle to progress than a clean sheet and a clear road. These are some of the arguments that readily occur to one. We have, to refute them, the whole, long, ghastly story of our failures and losses in previous wars when we depended on the 'chuck and chance it' method of preparation.

"Much interesting study might be devoted, also, to the economic side of unpreparedness. The effect of panic and haste on the prices of materials; on wages; on the expansion of industries to produce our first needs, as well as to supply our expenditure; on the eventual waste arising from such over-expansion; on the calamitous results flowing from these and kindred causes when a return is made to peace-time conditions. Such studies might be extended to include the ultimate beneficial effects which eventually compensate, to some extent, for these losses; the development of improved methods, and new and more productive machinery; the discovery of material substitutes; the adoption of standardization of products, etc.

"Perhaps all this must be left to the economists and philosophers, and our attention focussed on the military side of these problems. We may grant almost limitless advantages ultimately to arise out of the stress developed by unpreparedness, and still be strong in our belief in the wisdom and security of Preparedness, and in our purpose to contribute to a sane program.

"We must hope that we are safe in assuming that no officer of the Army or Navy who participated in the World War failed to be impressed by its mechanistic character. Discipline and soldierly fortitude are still essential to success; but these qualities—which, after all, are common to many armies—reinforced by the best mechanical equipment, are certainly superior when opposed to equal qualities and inferior mechanical equipment.

"The combat officers who did not recognize this at the outset were numerous and may be forgiven; but the combat officers of any nation who emerged from that struggle, unimpressed by the vital need for laying equal emphasis upon thorough industrial preparation and thorough military preparation, missed the greatest of the many lessons of the war.

"The trained procurement staff which will be provided by the Army Industrial College will be as necessary to success in another major war as the artillery or infantry. The man or the men who recognized this and therefore established this institution, and the men who now sustain it will find an enviable place in our military history.

"Conversely, those who are blind or indifferent to the significance and importance of this work thereby supply incontrovertible evidence that they have failed to learn the most impressive lesson of the World War; that they have not grasped the most significant element in all modern wars and that they are missing the greatest of all opportunities for developing economically and sanely the military strength of our country.

"We have the men, material, machinery and money. Only recognize that these may be economically organized and co-ordinated for war purposes and that all four are necessary, and the longest step toward the maintenance of peace will have been taken.

"Never forget that we have the material and resources to outgun and overwhelm any enemy, whether one nation or group of nations. When we fail in the beginning to do it, it is because our preparation failed.

"The object of combat being to dominate the enemy, it is a question only of conditions—whether this be accomplished by artillery, rifle fire, tanks, air control or any combination of these and other weapons.

"For simplicity let us reduce this, for a moment, to rifle fire. We have General Grant's opinion that 'The best way to subdue the enemy's fire is by a well directed fire from your own force.'

"To dominate, we must fire better than the enemy, an equal number of shots or as well as the enemy a greater number of shots. The meaning of this is, that to win we must be superior, militarily, by the training of our manpower or, industrially, by utilizing our superior resources, or both.

"Is it not, then, easy to conclude that the character of our people, the resources of our country, our world leadership in machine tools and other industrial equipment, our national program of mass production, and our national aptitude for mechanics make it the safest, easiest and cheapest course for us to protect ourselves and the weaker nations who may need our strength by a well developed program of industrial preparedness?

"To the new class, may I say that they are entering upon a work of limitless possibilities? If to contribute to our national honor; if to further our national ideals; if to safeguard the peace and happiness of the well disposed peoples of the earth be worth while, then this work is worth while—for it does all of these. And may your service here be the kind whose yesterdays look backward with a smile."

The members of the fourth graduating class of The Army Industrial College, whose course began September, 1925, and concluded January, 1926, were: Col. Irving J. Carr, S. C.; Lieut. Cols.: Wm. A. Wickline, M. C.; Frank H. Burton, Q. M. C.; James Regan, Q. M. C.; Harry B. Jordan, O. D.; Majs.: Richard Park, C. E.; Arthur J. Davis, Q. M. C.; Robt. P. Harbold, Q. M. C.; Thos. J. Smith, O. D.; Wm. N. Porter, C. W. S.; Wallace L. Clay, O. D.; Fred'k R. Garcin, C. W. S.; Roger Taylor, O. D.; Benj. G. Weir, A. S.; Capts.: Montgomery T. Legg, F. D.; Wm. H. Crom, A. S.; Carl C. Terry, O. D.; Ivan B. Snell, A. S.; Jas. H. B. Bogman, S. C.; Chas. A. Kraus, Q. M. C.; Harrie D. W. Riley, C. E.; Edward M. George, Q. M. C.; and Lieut. Reuben D. Biggs, A. S.

The members of the fifth class who are now taking the course which will continue until June, 1926, are: Col. Fred'k W. Van Duyne, Q. M. C.; Lieut. Cols.: John B. Huggins, M. C.; John E. Hemphill, S. C.; Comdr. F. R. McNair, U. S. N.; Majs.: Norman L. McDiarmid, M. C.; Robert Skelton, M. C.; Henry R. Smalley, Q. M. C.; Jeter R. Horton, U. S. M. C.; Charles T. Harris, Jr., O. D.; James H. Burns, O. D.; Maurice B. Willett, C. W. S.; Bethel W. Simpson, O. D.; Glenn P. Wilhelm, O. D.; Byron Q. Jones, A. S.; Alfred L. Rockwood, C. W. S.; Herbert J. Wild, C. E.; Keith F. Adamson, O. D.; Edmond deT. Ellis, Q. M. C.; Capts.: Oliver P. Echols, A. S.; Edward S. Pegram, Jr., C. E.; Emil H. Block, Q. M. C.; John Bigger, Q. M. C.; Jerry V. Matejka, S. C.; Charles J. Morelle, Q. M. C.; Lieuts.: Leland C. Hurd, A. S.; and Cortlandt S. Johnson, A. S.

OUR TOWER OF DEFENSE

AN EDITORIAL in the *Seattle Times* of recent date made the following appropriate and, we believe logical, comment concerning the appropriation of public funds for the upkeep and operation of our land and sea forces:

"There is no objection to the $100,000,000 air program proposed by a special House committee—provided all other arms of the service are correspondingly supported.

"We are willing to concede that the United States would benefit defensively from the expenditure of even so vast a sum as $20,000,000 per annum for a period of five years for the procurement and operation of aircraft.

"But, only on condition that corresponding and proportionate support was tendered the other branches of the military service.

"Concentration on aircraft is comparable with putting a fancy roof on a house—and ignoring the foundation.

"Or, furnishing the upstairs rooms and leaving the first floor vacant.

"Or, buying a $40 hat and letting one's toes protrude from broken shoes.

"There are plenty of predictions that the "next war" will be "fought in the skies."

"But, the Franco-Spanish campaign against the Riffs was waged by infantry chiefly, with supporting artillery, cavalry and armored cars. The French war in Syria is being waged by infantry, cavalry and artillery. When the Greeks and Bulgarians clashed on the Bulgarian border recently, the fighting was between opposing forces of infantry and artillery.

"Facts are unpleasant things, but they cannot be escaped.

"The facts of the military situation the world over are these: Wars on land still are being waged by infantry and artillery, with cavalry and airplanes as auxiliaries—important auxiliaries, it is true, but auxiliaries, nevertheless. Wars at sea are being waged by battleships, battle cruisers, destroyers, with submarines and airplanes as auxiliaries—important auxiliaries, also, but still auxiliaries.

"It would be the height of military folly to exalt the auxiliary at the expense of the main fighting force, or to build up the airplane and submarine to the neglect of the land army and the capital ship."

The Behavior Under Stress of the Iron Crystals in Steel

PART IV

By

H. H. Lester and R. H. Aborn

THE experimental facts in the upper part of the curves may be summarized as follows. There are no points in the stress-strain diagrams that may be definitely associated with the proportional or the yield points for the crystalline aggregates. The maximum strain values for the crystals of all materials tested occurred at approximately 80,000 pounds stress. The deformations for this stress were 54 per cent, 23 per cent and 18 per cent, respectively, for the blued stock, the low carbon stock and the annealed stock in the order named. Rupture occurred for the blued stock at 153,000 pounds per square inch, and for the other materials at about 90,000 pounds per square inch. From the photomicrographs we have the facts that the blued stock was troosto-sorbitic, the low carbon stock was a mixture of sorbite and ferrite and the annealed stock was pearlitic. Two points in the above summary of especial interest are the fact that maximum strains were recorded for approximately the same stress values and the relative magnitudes of those strains. It is not surprising that maximum values were found, but it is surprising that they should occur for approximately the same stress values in the various materials tested. Whether this is a significant fact or a coincidence must be left for consideration in the light of further experimental evidence. In the preceding section the different deformations for similar stresses are considered in the discussion of the different modulus values. The fact that some crystals had greater maximum deformations than others is important aside from the fact of different moduli. As we have seen from the discussion of stepped slip the factor that governs the amount of elastic deformation is the resistance to slip. This resistance was considered in that discussion as due to obstructions to motion caused by the pressures of adjacent crystals. A more complete discussion should consider also obstructions to motion that may exist within the crystal. It is perhaps generally conceded that freshly formed martensite consists of alpha iron crystals that contain carbon atoms within the iron crystals,[1] and that the presence of these atoms distort the atomic planes and in this way serve to obstruct movements along planes of possible slip. Due to the low solubility of alpha iron for carbon, however, the carbon that was in solution in the gamma iron supersaturates the alpha crystal causing a strong tendency to precipitation of the carbon. Jefferies[2] regards the carbon atoms as trapped in the alpha crystals in atomic dispersion, but considers that they diffuse out rapidly at a rate dependent on temperature, the carbon atoms as they escape forming not molecules, but crystals of Fe_3C. The cementite precipitation being nearly complete "at an early stage of tempering." He definitely rejects the idea of the carbide molecule. The above concepts with regard to carbon in martensite may be extended with some modifications to troostite and sorbite. There is a question in the minds of the writers at least as to the extent of the precipitation of cementite from the alpha iron crystals with different stages of tempering. If we assume that troostite and sorbite do contain carbon in solution in appreciable amounts we have at once an explanation of the facts that the troosto-sorbitic crystals of the blued stock were capable of greater deformations and had a lower crystal modulus while the material had greater strength. We cannot follow Jefferies in rejecting the carbide molecule. .It seems reasonable to suppose that with atoms, that have as great affinity as carbon and iron and that are in as close association as they would be when trapped in the crystal, there would be formation of Fe_3C molecules. We would expect that in the iron crystal one carbon and three iron atoms would replace four iron atoms occupying positions near to, but not quite coincident with lattice points in the normal iron crystals. Such an arrangement might not characterize martensite, but would give for troostite and sorbite, at least, a solid solution which we might designate as a molecular dispersion of carbide in alpha iron. In such solution there would be distortion of the atomic planes with greater resistance to slip and in consequence greater strength in the material, higher proportional point, and greater possible crystal distortion. Also the modulus for the crystal might be expected to be lower because in the molecular dispersion of carbide, the Fe_3C molecules occupy less space than the replaced iron atoms occupied, in consequence, the interatomic distances are increased in the region of local distortion causing a decrease in the interatomic forces.

There is some evidence aside from the larger deformations that support the idea of the solid solution. The spectrum lines for the blued stock were indefinite, those from the low carbon stock less so, and those from the annealed material were relatively sharp. Indefinite spectrum lines may be caused by very small crystals or by warped atomic planes. During the course of manufacture of steel ribbon there were small crystals formed. Whether these were sufficiently fine to cause indefinite lines is open to question. Tests performed during the progress of the present experiments on fine drawn tungsten wires did not show indefinite lines. The wires tested were 1 mil in diameter and were as drawn. It was considered that the

[1] Jefferies & Archer, "Hardening of Steel," Trans. Am. Soc. for Steel Treaters.
Bain, "Nature of Martensite," Min. & Metl., Feb., 1924.

[2] Jefferies, "Science of Metals" (1924 Edition), p. 425.

tungsten crystals had been subjected to a more drastic cold working process than the steel ribbons had endured. The fact that crystals below the critical size that give sharp lines were not found in the wire specimen was taken to indicate that no such subcritical sized crystals existed in the iron as a result of cold work. In a series of tests made in connection with another investigation steels of varying carbon content and having various heat treatments were found to yield spectrum lines that were very diffuse for martensite, less so for troostite, still less so for sorbite, and relatively sharp for pearlite. These specimens had not been cold worked, even the polished surfaces from which spectra were obtained were etched to remove any traces of cold work. The lines from the sorbitic and pearlitic specimens correspond to the lines found in the present investigation with respect to diffuseness. Jefferies claims very small crystals for martensite with progressive grain growth for troostite and sorbite. It would be consistent with his theory to consider that some crystals of subcritical size persist in the higher tempers and that these small crystals were responsible for the diffuseness noted, however, in view of the modulus variations and other evidence presented below it seems that the alternative explanation of the diffuse lines that involves warped planes is the more probable one. From this concept we infer that the plane distortion is due to carbon or carbide in solution and that troostite and sorbite represent different stages of carbide precipitation from the alpha iron crystals rather than different stages of growth of those crystals. Evidence gained from a careful X-ray study of a series of carbon steels indicates that there is no evident formation of carbide spectra from hypo-eutectoid steel till about the beginning of the sorbitic range. Moreover, at this point there seems to be a break in the hardness curve where hardness is plotted against draw temperatures. From the point where the carbide spectrum appears there is a continuous development of the carbide spectrum till it seems to reach completeness in the pearlitic range. These observations may be taken to indicate that carbide molecules separated from ferrite unite to form critical sized crystals in the sorbitic range. The spectrum lines are usually too faint to make positive statements as to their diffuseness, however, as far as can be determined when they appear they are fairly sharp. We have never observed diffuse carbide lines. If it should be that carbide crystals are practically never subcritical, the reason must lie in the fact that the crystal growth of cementite is so rapid that the subcritical stage is never observed. This would mean also that the observed development of the carbide spectrum may be taken to indicate the precipitation of carbide from the alpha iron crystals. We would have from this consideration sorbite distinguished by the gradual elimination of carbide from solution. Pearlite would be distinguished by the fact that carbide has been completely thrown out of the alpha iron and exists in equilibrium with it. Professor Honda[1] has put forward a somewhat similar view to the concepts we have expressed in that he considers martensite to be definitely a solid solution of carbon in alpha iron in which the carbon atoms occupy interstices in the body centered lattice of the iron. He places the carbon atoms at the centers of the cube faces. The indefiniteness of the spectrum lines he considers as due to distortions in the alpha lattices caused by the presence of the carbon atoms. He does not, in this paper at least, take up the question of troostite or sorbite. Honda's idea for martensite differs little from the concept we have suggested, except that he puts the carbon atoms in the face centers of the body centered cubes in the interstices of the iron lattice. To do this must involve a local stretching of the lattice and an increase in density of martensite. We have been unable to find evidence of increased size in the lattice of martensite though if the stretching is local such increased size would not be apparent in the spectra. The density would be increased, because the substitution of carbon atoms as suggested without the removal of an equivalent amount of iron would make each cube contain a certain amount of carbon in addition to its normal amount of iron. The available evidence indicates that the density of martensite is actually less than that of pure iron and is less than that of pearlite. Honda, himself, reports[1] the density of martensite as less than that of pearlite. Andrew & Honeyman[2] report that there is a constant increase in density with increasing tempering temperatures of martensitic material up to about 700° C. The range covered includes troostite and sorbite. Heindlehofer and Wright report similar observations on ball bearing steel.[3] From these density observations it is evident that the density of martensite is less than that of pearlite and that there is a gradual increase in density as pearlite is approached. The same thing is evident from the observations of Brush as noted by Jefferies.[4] This is contrary to what we would expect if the iron atoms were inserted as Honda suggests. The molecular dispersion idea where iron atoms are replaced by carbon fits in better with the density observations, because in this case the density of martensite should be less than that of pearlite and there should be a gradual increase in density of the solution crystals as we approach pearlite. The density of carbide is given by Westgren[5] as 7.68. If this value is indicative of the specific volume of the carbide molecule, this molecule should occupy about 20 per cent less volume than that occupied by four molecules of iron in the alpha crystal. It seems reasonable to suppose that such a molecule could exist within the crystal without undue lattice distortion. The distortions would tend to increase planar spacings and thus reduce atomic forces in adjacent planes. The volume occupied by the carbon atom is, however, comparable with that occupied by the iron atom and seemingly too great to be consistent with the interstitial intrusion idea. On the other hand, the density of eutectoid martensite is somewhat greater than it would be if all of the carbon were in solution as carbide in iron. We would have in this case for each cube 1.92 atoms of iron and .08 atoms of carbon, the density of the cube would be 7.58. If all the atoms were interstially inserted we would have a density of 7.90. The density of martensite is around 7.75. It seems necessary to assume for martensite that some of the carbon may be in solution as carbide in iron and some of it may be outside of the crystal or may be within the crystal in the manner suggested by Honda. The gradual increase in density as we pass

[1]The 103rd report of the Research Institute of Iron Steel and other Metals, April, 1925.

[1]A. S. S. T., Vol. 4, p. 462—1923.
[2]Andrew & Honeyman, Carnegie Scholarship Memoirs, Iron & Steel Inst., p. 253—1924.
[3]A. S. S. T., Vol. 7, p. 47—1925.
[4]Jefferies, Science of Metals, p. 430.
[5]Westgren, Jour. Iron & Steel Inst. No. 1—1924.

through troostite and sorbite seems to be consistent with the gradual development of the carbide crystals found from X-ray data and with the idea of the gradual precipitation of carbide from solution as considered here.

The lower modulus and the greater distortions recorded for the sorbitic material seem to require explanation on the basis of some such idea of a solid solution. We have in the modulus of the crystal a very fundamental physical property. It is difficult to picture changes in this property without regarding them as due to fundamental changes in the atomic forces within the crystals such as would be caused by the introduction of different atoms or different atomic arrangements. If molecules of Fe_3C do exist within the iron crystals and if these molecules occupy less volume than the displaced iron, their presence would tend to increase atomic spacings and probably decrease atomic bonding. There should be in consequence a lower modulus. The fact of greater deformations is as readily explained, because the local distortions in the iron crystals would tend to prevent stepped slip and periodic recovery and would in consequence cause greater tensile distortion. It should be remarked in this connection that the recorded values of crystal deformation seem to be inconsistent with the values of the moduli for the crystalline aggregates. It must be borne in mind, however, that in the crystalline aggregate the modulus considers both the crystalline forces and the forces binding crystals together. It is possible for the crystal to deform by an amount inconsistent with the deformation of the aggregate if we consider that the crystal bonding is relatively more rigid than the atomic bonding within the crystal and if we assume that there is in sorbite a relatively large amount of the bonding material or of other material relatively more rigid than the iron crystals, such, for instance, as precipitated cementite. It might be argued that the observed values for the blued stock contained large errors, because of the diffuseness of the lines and the difficulty of reading accurately. The difficulties of measurement did enter and these values are not as reliable as the values for the other lines. Probably it would be safe to assume that the shifts measured are accurate to within 20 per cent. The fact that the line shifts were much larger than was the case for the other materials was evident from a visual comparison of the films the blued stock films showed definite shifts that were evident without applying the measuring instrument while with the other materials one could not be sure that a shift existed in all cases until the lines were carefully measured.

The assumption of a solid solution of the kind suggested explains the diffuseness of the sorbitic lines. The lines were indefinite, because of distortions in the iron crystals, as Honda contends, although there is a likelihood that there were also small crystals present. The drastically cold worked material might have contained residual strains which would account for distortions. This possibility is not supported by the experimental evidence, because if the diffuseness of spectrum lines were due to residual strains these should be removed upon applying stresses with resulting sharper lines, no such clearing up of the lines was observed. The material might have contained subcritical sized crystals and the diffuseness observed might have been due to these as contended by Jefferies in explaining martensite. These small crystals must have come from the effects of cold work or else from the retarding action of carbon in preventing crystal growth. However it seems to the writers that there is sufficient evidence for distorted crystals, that distorted crystals do produce diffuse spectrum lines, and that the introduction of the concept of small crystals is not necessary for the purposes of the present investigation. For this reason the question of crystal size is left for consideration in reports of other work.

We have thus from the conception of a solid solution of carbide in alpha iron a logical and consistent explanation for the smaller crystal moduli for the sorbitic materials in comparison with the annealed material and for the lower crystal modulus of the high carbon in comparison with the low carbon stock, since this material contained less sorbite. Also the diffuseness of the spectrum lines is satisfactorily explained and the relatively higher elastic limit of the sorbitic stock.

Summary of Conclusions

The experimental results recorded above must be considered in the light of limitations imposed by the experimental difficulties and the fact that only three materials were investigated. They represent a more or less incomplete study in spite of the fact that a great deal of labor was expended in getting them. It is probable that the extension of the work with more refined methods of measurements and a wider selection of materials will modify the results to some extent. It is possible too that some question will be raised as to the interpretations that have been placed on the data. In the view of the writers present data justify the following general conclusions:

1. The stress-strain relations for the crystals in the crystalline aggregates do not follow the smooth curve that characterizes those relations for the aggregate.

2. The irregularities noted indicate that the crystals undergo strain recoveries on application of increasing stresses to the aggregate, and on removal of load may be left under stress, sometime in tension, sometime in compression.

3. The strain recoveries may be explained as the result of "stepped slip." Stepped slip is defined as small movements of atoms along planes of slip relative to atoms in adjacent planes of the same planar system after which movements the atoms are left in the same geometrical configuration that held before the motion started. One step in the slip would be the distance in the direction of motion between two equivalent positions of stability in adjacent crystal units.

4. Stepped slip is distinguished from block slip in the facts that the former involves relatively smaller movements, does not produce visible slip bands, and does not cause disorganization of atoms along the path of motion. It is regarded that block slip involves larger motions, the motions are restricted to fewer planes, and are accompanied by the production of disorganized material along the paths of motion, and by the production of slip bands that when sufficiently developed may be seen in a microscope. The two types of slip are regarded as merging with an indefinite line of demarkation in the region above the proportional limit and below the yield points for the aggregates.

5. The proportional and yield points of the aggregates are not represented by corresponding peculiar points in the crystal deformations. By inference these points may be regarded as associated with intercrystal bonding and with the rupture of crystals along slip planes rather than

with inelastic properties in the crystals themselves. The proportional point does seem to be associated with the region in which block slip begins to be imperfect, and with the initiating of imperfectly developed block slip. The yield point marks the region of well developed block slip.

6. For stresses below the proportional limit of the aggregates the modulus of the crystal is the same, within limits of accuracy of the determinations, as the modulus of the aggregate. This fact is taken to indicate that for this region the elastic load on the material is taken by the crystals of the material.

7. For stresses above the proportional limit the apparent crystal moduli of the annealed and low carbon stocks were abnormally high. These facts were taken to indicate that some other constituent besides the iron crystals was present, that this constituent was developed above the proportional point, and that this constituent had a higher modulus than the iron crystals. This constituent is taken to be material in which the iron atoms are disorganized or are in an essentially amorphous condition. The disorganization is regarded to be the result of imperfect stepped slip or the disarrangement of atoms that accompanies block slip.

8. For stresses above the proportional point for the sorbitic, or troosto-sorbitic blued stock, the crystal moduli showed little variation from that of the aggregate. This observation may be interpreted to mean that very little disorganized material was formed or else that the amorphous material formed had a lower modulus due to the presence in it of carbon atoms.

9. The sorbitic or troosto-sorbitic blued stock showed a lower apparent crystal modulus than those found for the other materials. Also the spectrum lines were diffuse. These observations are taken to indicate that there was in this material carbon as carbide in solution in the iron crystals.

10. The solution of carbide is defined as a molecular dispersion of carbide in the alpha iron crystals in which the four atoms of the carbide molecule replace an equivalent number of iron atoms and occur at points somewhat removed from the lattice points of the iron crystal. The solution is not regarded as stable, but as having pseudo-stability due to the high viscosity of the iron crystal.

APPENDIX

Review of Literature on the Elastic Deformation of Metals As It Relates to the Problems of the Present Investigation.

THERE seems to be no work similar to the investigations reported in this paper that has appeared in the scientific press. Joffè[1] and co-workers[2] worked on single crystals of rocksalt which were subjected to compressions. They found the elastic constants of the individual crystals. There has been some work reported on the deformation of single crystals of metals, but most of the investigations have been concerned with the region above the elastic limit where the single crystal has broken up into a number of crystals so that the titles are misleading. Mark, Polanyi, and Schmidt[4] investigated the stretching of zinc crystals, and later Bi, Sn, Cd, Pb, and Al, crystals. Carpenter and Elam have studied deformed Al crystals. Czochralski[7] and Gross[8] found that there is an analogy between the deformations of NaCl and mica crystals and those of metal crystals. Professor Bridgman at Harvard has obtained the elastic constants for single crystals of a number of metals[9] not including iron. Osmond and Fremont[10] have studied the mechanical properties of a single crystal of iron formed in the back stay of an open hearth furnace. Edwards and Pfeil[11] have produced artificially single crystals of iron and have reported their mechanical properties. O'Neill[12] reports a stress strain test on a single crystal of silicon iron. He found an apparent elastic limit under 5,000 pounds per square inch. He compared the tensile strength with that of similar material, that was made up in the usual way and consisted of many small crystals in an aggregate. The tensile strengths were approximately the same, but this comparison means little because in the process of getting the tensile strength of the crystal it was plastically deformed and became a crystalline aggregate so that the results found were in the end from similar materials in similar conditions. The theory of elasticity for crystals has been worked out very carefully by Voight[13] and the development of the theory of elasticity for crystals has been summarized by Ewald.[14]

Metals that enter into industrial uses are, however, not made up of single crystals, but are crystalline aggregates and the properties of single crystals cannot be applied easily to the aggregate. While no great amount of work has been done on the stress and strain distributions in the individual crystals of such aggregates there have been many investigations of elastic behaviors of aggregates. Among studies most pertinent to this problem may be mentioned those of Professor F. C. Thompson and his co-workers[15], [16]. These papers have dealt with the application of surface tension hypotheses to account for the intercrystalline strength of metals in which the idea was advanced that the elastic limit and yield points are primarily dependent on the condition of the intercrystalline medium. More recent papers have dealt with plastic deformation in alpha and gamma iron[18] in which some very interesting concepts have been given concerning the mechanism of plastic deformation, and with the effect of free surfaces on plastic deformation[19]. In this paper the idea is developed that elastic failure in the surface layer of a test specimen occurs at a lower stress value than that at which the inner metal fails. Here again is emphasized the idea that the elastic limit and yield points depend primarily on the physical characteristics of the test specimen rather than on the characteristics of the primary structures in the specimen. Saklatwalla[17] has stated that he considers the elastic limit and the endurance limit to be functions of the intercrystalline medium. Belaiew and Goudston[20] and Warzinirk[21] consider the proportional limit to be a function of the test conditions and the previous treatments given the specimen. Professor Edwards[19], discussing Thompson and Millington's papers states that for a long time metallurgists have noted evidences of yield below the elastic limit. Fraishet[22], studying the tensile deformation of steel by magnetic methods, reports the real elastic limit as occurring at stress values from 10 per cent to 50 per cent below the indicated proportional point, depending on the treatment of the metal. Geiss[23], Hedrick[24], Thompson and Millington[19] and others have reported that Hooke's law has been found to be inexact over the entire region below the elastic limit.

Papers that have dealt with deformation problems from theoretical considerations have been given by Rosenhaine[25],

who advances the idea that when the crystal lattice is distorted under stress the limiting parameter is reached at the stage of elastic breakdown, and a new phase, an under cooled liquid, is formed. Professor Jenkins[26] used models to interpret stress strain curves of metals under varying conditions. Ping pong balls are used to represent atoms and characteristic crystal structures are built up. It is doubtful if a correct representation can be had in this way, but the models serve as useful bases for theorizing. He reports that the models will not interpret actions within the material above the yield point because of mutual interference of crystals. The observations in the present paper indicate that this interference occurs much below the yield point and even below the elastic limit.

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Technical Bulletins on Nickel Steel

A GREAT deal of interest has been aroused, particularly among members of the Army Ordnance Association, by the publication by the International Nickel Company of a series of technical bulletins on alloy steels.

Bulletin No. 1, "Society of Automotive Engineers, Standard Specifications for Steels," and Bulletin No. 2, "Physical and Mechanical Properties of Nickel Steels," have been published, and through the courtesy of the Company have been distributed gratuitously to members of the Army Ordnance Association and other technical and engineering societies. The Company also furnishes a serviceable loose-leaf binder to facilitate filing and thus increase the reference value of the series. The bulletins are of convenient size, 5⅝ by 11⅛ inches, printed in large type, with illustrative charts and tables.

Members of the Army Ordnance Association who are interested in this important literature which has such an intimate connection with munitions and who have not received Bulletins Nos. 1 and 2, can secure them and the remainder of the series as issued by addressing the International Nickel Company, 67 Wall Street, New York City.

Editorial

Power: A Factor in Munitions Preparedness

THE reader will have observed that this issue of ARMY ORDNANCE is devoted largely to "power"; we might say electrical energy, for the terms have become almost synonomous in the public mind. It is a subject of general interest; one which commands attention in almost every walk of life. In the category of public service it has a place beside transportation and the various means of communication.

Electrical energy is a requisite of numberless activities. It turns the machinery of our factories; it moves our cars and trains; it lights our streets, our work-shops, our mines and our homes. It brings a red glow to our household utensils; it brings to white heat our great industrial furnaces requiring the high temperatures obtainable in no other way; it separates compounds into their component parts and supplies materials that otherwise could not be produced. It is used in the deposition of metals in refining and electroplating; it produces the X-ray and it—but its field of utility is limitless and the mind of man has not yet discerned its bounds.

The interest of the preparedness advocate is that of one of many consumers of power. In time of war great quantities of power are required and must be procured in such a way as to cause the least possible disturbance to the peace-time activities of the country. To this end acquaintance with the power industry is essential, and a general understanding of the fundamental principles of production and distribution of electrical power will do much to guarantee a sound solution of the many problems that must inevitably arise.

In as far as it may be possible the power required for Ordnance manufacture in war will be drawn from established systems. This is in accord with good practice and sound economy since the establishment of independent power plants in war is time-consuming and expensive, especially if the facilities are to be used during the emergency only. Should war unfortunately come again, there probably will be little need for the construction of separate power plants. We grant that during the World War it was necessary in some cases to do so, but conditions have changed so rapidly that there is every reason to believe that the Ordnance problem in any future emergency can be solved without the necessity of new electrical power projects. It will be by war-time expansion in accordance with projected plans of the existing power systems, using to the fullest extent the experienced personnel always to be found in charge of such facilities, that special situations will be cared for.

To the Corps of Engineers, U. S. Army, is due a great deal of credit for the present high state of preparedness on the part of the power industry of America. Charged with the active operation of the Federal Power Survey, this branch of the Army is probably doing more in its field than any other agency toward the development and maintenance of an adequate power supply for emergency use. What has been written in this issue of ARMY ORDNANCE by the several officers of the Corps of Engineers who have contributed articles, bears out this statement in ample degree.

What has been said of electrical power is not, of course, true of steam for use as such in manufacturing or for heating purposes. It will probably always be necessary to provide a boiler plant wherever steam is required. Colonel Waring, in his contribution to this issue, discusses the many phases of this sphere of power and the national defense.

In presenting this Power Number of ARMY ORDNANCE the objective has been the visualization of the very close relationship of power to preparedness, the tremendous power requirement of Ordnance in war time and the gigantic strides that have been made by the American power industry during the past decade. Thanks to the genius and ability of those who are pushing forward the peace-time development of electrical power, it seems quite certain that in another emergency the power industry as a unit will be able to repeat the historic reply of the Admiral of the British Fleet to the laconic inquiry "Are you ready?" flashed to him in August, 1914. It will be remembered that the terse reply came back immediately, "We are." So also American power should any unfortunate circumstance require that the question be put.

Congress at Work

FOR the sake of erasing from the minds of some what may be a very hazy and negative opinion of Congressional activity in its relation to preparedness, we take the liberty of quoting from the *Congressional Record* of February 11, 1926, during the debate in the House on the Army Appropriation Bill for the fiscal year 1927.

Those who have been insisting for years back upon the necessity for an adequate ammunition reserve for the proper balancing of our ordnance program may well congratulate themselves that this vital topic is receiving serious consideration on Capitol Hill. What greater proof of this statement need be made than a quotation, the remarks of Mr. Anthony (Kansas) in presenting the bill in the House of Representatives. He said:

"There is another unusual feature in this bill, and that is the fact that this is the first time since the War when we are making appropriations to augment the reserve which we have set up each year. A number of years ago we provided that reserve supplies should be maintained in the War Department for use in time of emergency of an

Army of 1,000,000 men. The Army since the War has been steadily living upon the surplus inherited from the Great War. It has not only been living upon that surplus largely, but we have been invading the reserve that we have ourselves set up by legislation, requiring the War Department to hold for an Army of 1,000,000 men. So that this year, if you desire to maintain that reserve for 1,000,000 men intact, we found we would be compelled to make some provision for renewing ammunition and clothing supplies which had been invaded largely for the use of civilian components of the Army. * * * *

"The evidence has shown that the life of the larger sizes of fixed ammunition is practically unlimited, but it is true that in some of the smaller sizes, like caliber .30 shells, this year for the first time we found deterioration in the supply, and there is $1,300,000 appropriated in this bill to commence to build up our supply of caliber .30 rifle ammunition, which we found to be deteriorating. Six million dollars is carried in the bill to build up these reserve supplies, and in order to take care of that $6,000,000 increase and not bring the totals for military purposes above what they are this year, the War Department was compelled to make these arbitrary reductions in those items that I have spoken of, and we were compelled to make an increase over the amount recommended by the Budget."

Nor is the championship of this cause confined to any one man or group of men in our national legislature. Speaking on the same day, Mr. Harrison (Virginia) made these potent remarks anent the housing situation and the deterioration of plant and equipment at Army posts and stations throughout the country. He said:

"So when the War was over and we were preparing a peace-time status of defense it was provided that we should have a reserve of equipment, ammunition, and guns for a million men, and that has been encroached on and such encroachment is not taken care of. Now, it may be all very well for people who do not desire large military establishments to say we should allow our Army to dwindle and our National Guard development to be halted, our reserves to go untrained—I say that may all be very well to those who are opposed to any adequate military establishment, but I think that the people should know such impairment of the military defense as lack of funds necessitates. About these matters there may be difference of opinion.

"The great feature in this bill which I think is most objectionable and deserves criticism is its failure to properly care for its military establishments. The condition of the forts, arsenals, roads, housings, and hospitals are in a shocking condition from lack of the most necessary repairs. Anyone who visits any military plant will be shocked at its deterioration. I read from what Secretary of War Davis says:

"'I have not hesitated to say quite frequently that I think the condition of our housing is a very serious matter, and almost amounts to a national scandal.'"

Concluding a debate characterized by a clear knowledge of facts and a determined interest to remedy conditions, Mr. Harrison said:

"Why should not this country run its business just like any ordinarily prudent man would run his business? Why should we stand by and see our plants, so to speak, go to pieces and the necessary forts established for the protection of our cities fall in ruin? The whole proposition amounts to nothing except postponing the day when this country will have to make the appropriations at a greatly increased cost."

It should be a consoling thought of friends of preparedness to read the above quotations by champions of their cause spoken in the House of Representatives. Certainly no more praiseworthy nor more enlightening stand on important questions relating to the welfare of the Army in general have been spoken from this high place. Such a stand on the part of Congress is cause for gratification and congratulation among advocates of adequate national defense.

From Generation Unto Generation

COL. FRANK A. SCOTT, in his address to the graduating class and new students at the Army Industrial College, February 1, 1926, sounded what to us seems to be a very important keynote. His entire address is fraught with wisdom based on experience and mature reflection, and any pronouncement which he makes on the question of industrial preparedness can always be depended upon to state the question fairly, analyze it succinctly and suggest courses of action both feasible and necessary.

There is one thought, however, in Colonel Scott's address which we take the liberty of commenting upon because of its important relation to the furtherance of any preparedness plan.

Quoting from the *Memoirs* of Earl Gray, Colonel Scott emphasizes the necessity of impressing upon our younger men the need for an adequate realization of the problems of preparedness. The present generation which has lived through the experiences of the World War and which knows and understands the requirements and obstacles that have to be overcome in a major emergency, is not the most important element in the matter. After all, it is the coming generation for whom provison must be made that our lessons of the World War are not forgotten. It is a trite expression these days to hear that our country has experienced some major emergency in at least every second generation. It seems that by some natural law when one generation of experienced people has passed away another by reason of its inexperience falls into the difficulties of its predecessors.

Therefore this process of handing down lessons of the past and present to our successors is a most vital one. It will be a happy day when the rising generation, upon whom the burdens of the coming years will fall, is equipped through study of our World War experiences to carry on mindful of the mistakes and shortcomings of the past and intent upon profiting by the lessons of the past. This is a tremendous responsibility which devolves upon those who know and understand the situation. Today when some of our so-called institutions of learning are opposed to the instruction of students in the fundamentals of military training under the absurd and flimsy excuse that such training tends toward militarism the problem is doubly hard and places added responsibility upon all of us who realize the necessity of passing on the heritage to our leaders of tomorrow.

Historical

Edited by Maj. William A. Ganoe, Inf., U. S. A., Historical Section, Army War College.

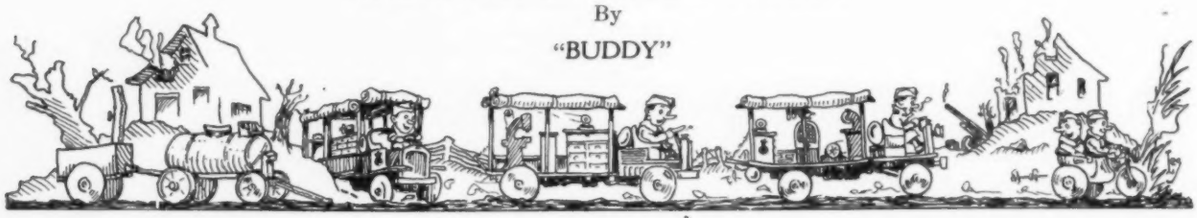
IN the last issue of ARMY ORDNANCE attention was directed to some of the ancient and honorable methods of ordnance manufacture and test of a century and more ago. So rather than make the procedure of the dim past appear too grotesque, it has been thought proper to bring the readers' attention to other phases of ordnance which, while not yet cloaked with the mantle of time to any considerable extent, are still history in the real sense of the word.

We shall therefore consider the trials of one who, during the World War, served in a most active capacity. Too modest to appear over his real name, the author, a former Ordnance soldier in the A. E. F., has adopted the *nom de guere* "Buddy," which, as the narrative unfolds, proves to be an apt selection. In the following episodes, not without their homely humor, can doubtless be detected some unique phases of important ordnance history.

A. E. F. ORDNANCE NOTES

By

"BUDDY"



BUDDY once had a boss who said, "You're like a grasshopper, you jump—and land afterwards." So true to form in 1917 he jumped into the Army and landed in the Ordnance. As the fatalist says, "It was meant to be," for he had been turned down by a hard-boiled "Regular" recruiting sergeant looking for sharp-shooters without spectacles; and had written a bushel of applications to Washington trying to tell Uncle Sam he was the best little ordnancer who ever greased a shovel. Being naturally lucky and not knowing it, he was drafted early and dropped into good old Sandy Hook in the lee of the proving ground. It's a wonder he wasn't shot as a spy, for he climbed trees to see the gun crews work, was blind to "Positively No Admittance" signs, had a German name and in general made a snoop of himself. One who has mechanics born in him, war or no war, is just awfully inquisitive, when he gets so close to such a collection as that proving ground and shops had in December, 1917.

From a drafting room to "Squads East" in sand that ground the toes off your "Civi" shoes, soon had him hardened enough to walk to Berlin. Believe me, this hardening is needed by every Ordnance man who is going into real field work, such as "John" dealt Buddy's outfit in the Argonne.

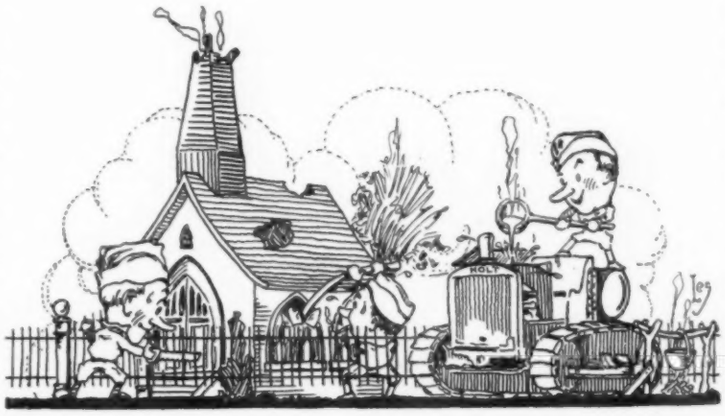
His ordnance work at the Fort consisted mostly of quarantines, arm shots and Old Guard fatigue, and much valuable time was lost that could have been used for actual study and practice on machines that would inevitably be used overseas. However, Buddy made himself useful and set up furnaces in barracks that the cost-plus contractors couldn't understand, learned coast defense gun construction and firing, and Packard "Border" Truck habits.

Buddy was issued a S. & W. .45 pistol to carry over. Mostly to carry over, because he never used it, only to sleep on sometimes. A gun is about as useful to a mobile ordnance man as cuss words to the chaplain. He nearly wore it out cleaning for inspections before going to the Front and after trying to tie it all over his anatomy while working, he finally hid it away on the Brill Truck. Now, if an ordnance man really needs "irons" at the front, and is a fair ordnance man, he'll just naturally pick up some of the best specimens from salvage. Buddy recollects having a perfect Springfield, Enfield, French "Long Boy" and Erfurt with plenty of "Brass" for each, right handy under the roof of the Brill repair truck.

The Ordnance School at Libourne was getting under way in June, '18, and was the first real step in our training; but personnel was lacking and Buddy soon found himself teaching a class of sergeants, corporals and privates, 1st class, the A B C's of gas engines. Can any "Old Timer" imagine a buck telling a sergeant anything? Yet, that little shop with only the rudiments of material, a few salvaged French pleasure cars, a Holt tractor and a 155 G. P. F., produced one Ordnance Detachment that later Buddy was proud to be a member of.

A 40 h. p. Bessemer raw fuel oil engine had been sent to this repair shop to furnish the necessary power. A lad from a nearby Engineer Detachment was attempting to set up this unit, without much knowledge of it. When Buddy petted the cylinder and made known the fact that he had been setting up and testing the Bessemers, he was promptly introduced to the officer in charge and arrangements were made to supervise the work. He found the bed plate securely bolted down to the concrete foundation

so that no air could pass into the air intake, so we had to chip a suitable opening through the concrete. That Engineer lad surely knew how to make real concrete. No exhaust pipe came with the engine so we spent about three days around Bordeaux trying to get 6-inch U. S. I. P. Everything was metric so we finally brought back enough of the nearest size and figured on making a good concrete adapter. I suppose this is a good argument for universal use of the metric system industrially but I'm neutral. Buddy never saw that engine run as his outfit moved on to field practice in another town. After the Armistice he was fortunate enough to again visit this shop and found the Bessemer had never been completed, a Packard truck engine having been belted to the line shaft to furnish power.



Buddy's next experience was field practice with G. P. F.'s, Holt 150's and O'Grady drills. How many Ordnance men know what an O'Grady drill is? Well, anyway, what "O'Grady sez" is mighty good training in concentration for anybody. During this period, Buddy got familiar with the construction and operation of the Filoux gun and how to manage a husky Holt without breaking his wrist watch. However, we were spared the troubles of the monsters as No. 75 Holts were finally issued to chase Heinie, and I believe won the war as far as heavy artillery is concerned. They were delivered to us directly from the steamer decks, but all were cleaned of salt water and put in running order on the cars going up to the Front.

We unloaded at Void, and found the hard French highways soon tore off most of the cleats on the caterpillar bands. Moral: don't use cleats on hard macadam roads, they injure the road and must be collected.

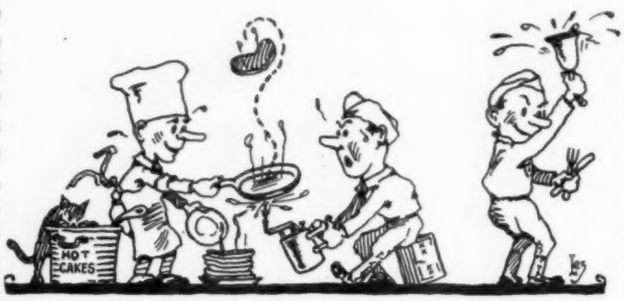
Our next trouble was encountered with the armor plate hoods over the engines. They retarded repairing speed, were not needed and eventually were entirely removed. Note the word "speed" because a tie-up in a convoy delayed the whole "Circus." Here arose the phrase "Pull in your neck and let the convoy by." Many times a stubborn piece of equipment would be tossed into the ditch rather than have a "Parade" exposed to daylight.

Up front at first the Brill repair trucks endeavored to skip around to the various break-downs. This proved unsatisfactory as the roads were jammed, and drivers, not having maps, got lost from the outfit. We finally established temporary bases bringing the Ordnance Detachments together and sending men and trucks out to handle the repairs or to bring in the broken parts to the bases. Buddy expects the Air Service will handle this transporting detail in the next fracas. Certainly, a repair parts plane would help in many a pinch, where trucks could not get through, or were too slow. However, Buddy learned to love the Brill repair truck, and used her to good advantage, but like most mechanical devices, there were chances for improvements.

Weight, that bugaboo of all transportation, needs considerable thought. The old Brill glided off the loading platform near Bordeaux and dropped through the floor of the dinky French flat car, thus delaying movement, and requiring a corps of men, several gun jacks and some bad language to get heavy planks under the truck wheels and lashing to the carriage. Again and again, at the Front, while driving in the dark, one wheel would find a shell hole we had overlooked by cigarette light, and then our crew would pan out the loose dirt by hand, jack up and build a little Napoleon Rue under the wheel, by which Buddy would drive to *terra firma*. Another favorite midnight pastime was ditch sliding. On narrow high crowned wet French roads, it was sometimes necessary to allow other cars to pass by. This was accomplished by pulling away over to the edge, pitch at an agle of 45° and pray. If we had good luck, we held, but if not, some good natured tractor driver would haul us out of the ditch. Hard rubber tires + wet French roads = ditch. (Chains were forbidden by some unknown general.) Buddy never was able to stall the good old Wisconsin motor in the F. W. D. but neither could he get traction enough to pull out of the holes. Double rear wheels with tractor bands should be used. They are slow—but then we never planned to retreat.

We used to admire the tank driver. He was inside, out of the weather and protected (?). Buddy finally built a little iron work over the driver's seat and stretched a shelter half over it. This, like the tin hats, gave a feeling of protection and kept the rain off. Naturally, we felt more like working after a long trip to a broken gun in the rear. A cab should be provided but light weight and waterproof.

It is often said that a church is a good thing in a community, and it certainly was in Romagne. We were out of babbitt and firing pin raw material. A Holt needed a new main bearing, so I lost my Presbyterian faith temporarily, and took enough lead from the broken church window to add to the remains of the burnt bearing, so we soon had another Holt in commission. Again, the church didn't need all the iron fence, so we sawed out a few bars and turned up some firing pins for the 1st Battalion G. P. F.'s. Fence palings don't temper well, but I had grabbed some cyanide in Libourne and the gunners reported that the case hardened pins lasted longer, probably being a snug fit. Another hold up was avoided by cutting up a brass hose bibb from a chateau to repair a Dodge broken gas line. A truck steering lever was cut down and used to replace the broken lever on the Dodge. German fixed ammunition shells were hammered to shape for pads on frozen Dennis radiators and so on. I'm trying to show how raw material can be picked up by a thoughtful mechanic, also, that raw material plays an important part.



A portable blacksmith's forge was one of the handiest things we stole from the French. "Slim" Williams, our blacksmith, could fashion most any forging we needed and for welding in the rain the forge was indispensable.

Speaking of welding, at Montfaucon a 155 G. P. F. blew from defective fuze and to keep a secret from Heinie, we were asked to cut it up small enough to load into trucks. We had to carry the gas tanks about 400 feet through mud and shell holes. Carrying devices should be attached.

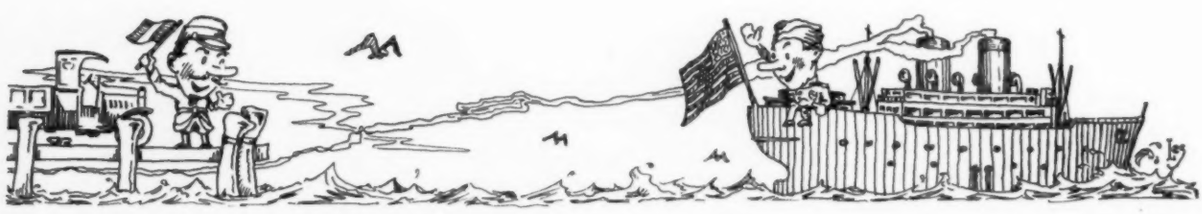
At Esnes, one night, I had nine men sleeping on the Brill. It appealed, because it was clean, dry, and cootiless. We used the gasoline plumbers torch for heating. Incidentally, we never had any cooties as long as we stuck to the truck for sleeping quarters. Thus, sleeping quarters on the floor, tail board, bench, etc., might be considered.

Sometimes, the Ordnance Detachment had a chance to eat, but more often, we had been sent away from the "grease balls" so it was necessary to beg, borrow, or steal. Finally, we secured an emergency ration box and rigged up a hot plate to fit the gasoline torch. Our reputation for good flap jacks soon gave us plenty of company. We also used a "Sterno" solidified alcohol stove until the canned heat was gone. Some thought should be given for provisions and a small cook stove.

At the Front, firing every two minutes, would snuff out our candle lights in the truck. I also discovered it broke the filaments in our spare electric bulbs so we moved out of the cycle of concussion. A few days later we picked up a German storage battery for field telephones. This, we wired up to a six volt bulb in the top of the truck. This auxiliary saved gas in the generator set and served nicely during gas alarms and night calls for parts. The battery was kept charged by the Signal Corps outfit for past favors in repair work.

One night on the hill above Romange a First Battalion G. P. F. was reported damaged. Two gun axle spring studs were snapped off short, the gun was in firing position and would stay that way unless repairs were made. Buddy grabbed a handful of drills, some drifts, a stilson and a breast drill, jumped into the waiting Dodge and soon was on his back under the gun. Sure enough the 1-inch studs were broken off flush, so starting with a 1/8-inch drill, and increasing each succeeding one, I had two drift holes in about an hour. Dew laden with gas dripped off the camouflage overhead and liberated enough to make the job miserable. I drove in one drift, applied the wrench and dug my shoulder into the German paper sand bags. The stud moved and I could have kissed the Frenchman who assembled the gun for he had used some graphite grease in driving the studs. A good point learned!

Along came Armistice Day. The gunners burned their powder and asked "When do we go home?" but the Ordnance worked on. A long parade back to Wassy kept the detachment busy, but made a record trip. Buddy had to repair the typewriter that wrote the passenger list of the boys going home, but we stayed with the Brill. She was cleaned and scoured, inspected and re-inspected. Then Buddy was ordered to check up and turn it in. Arriving at the receiving depot, I was ordered to drive it into line with others, axle deep in mud, so bad we had to put on our boots to carry our kits away. Maybe, somebody got an overstuffed Ordnance Repair Outfit for we checked up with every tool present and also some twenty-odd extra tools made or "borrowed" from various sources. A checking list would have been handy, along with some system of letting out tools to the mechanics. Anyway, it was a good war while it lasted.



Theater of Operations

Edited by Maj. T. A. Clark, Field Service, Office of the Chief of Ordnance

Ordnance Service with Troops

Command and Staff

IN TIME of peace, prepare against war! What better slogan can the Army adopt? How expressive of the true mission of modern military organization. The happy substitution of the word "against" in place of the erstwhile "for" as brought out by a recent Secretary of War is indeed an innovation. It expresses the true mission without detracting from its force. It leaves the pacifist in a maze. To it he can offer no valid objection.

The purpose of this page is to discuss one phase of the duties of the Ordnance Officer in his preparation against war, i. e., to determine in the calm of peace his exact place in the great war machine at the Front so that in the excitement incident to the precipitation of the conflict he may know his exact status; his relation to command, staff and troops; what is expected of him and how he can best accomplish it. One of the objects is to interest and instruct the young Reserve Officer along an elementary and popular line in an attempt to clear up some of the generalities that usage has contributed to convenience. Generalities, after all, are merely convenient terms that cover multitudes of specifics and in order clearly to comprehend a generality one must be familiar with the concrete ideas which it embraces.

Two glittering generalities that always muddle the mind of the tyro and are not any too clear to many advanced students are the terms "command" and "staff." What do they mean? What is the difference between them and, most important of all, where is the line of demarcation between them? The toiler in the Leavenworth correspondence course receives these definitions: "Command is the authority which a person in the military service lawfully exercises over his subordinates." "Staff is a term applied to the personnel who help the commander in his exercise of the functions of command by professional aid and assistance." No criticism of these definitions is offered or intended. As definitions they cover the ground completely. But the student soon finds himself in a quandary as to their interpretation and as to the distinction between them. One reason for this is the generality of the terms used and another is the use of the word "command," sometimes as a noun and again as a verb. The above definition of command covers its use as a noun only. The meaning of the expression employed as a verb is obvious for the reason that it is familiar to the layman; the noun, however, is usually distinctly military. In the popular sense "to command" means "to order." However, the expression carries with it more than an order; it implies strict and immediate obedience to the order upon pain of penalty. An order is commonplace but a command is dramatic. The foreman orders his workman to cut down a tree but the New England constable, mounting a watering trough in front of his cordon of policemen faces the mob and cries out, "In the name of the Governor of the Commonwealth of Massachusetts I command you to disperse!" A military order either written or spoken is understood to carry with it the force of a command and the authority to exact obedience thereto gives rise to the noun "command." The noun is ordinarily used in distinction to the word "staff"; of which, more anon.

Military men love to think of Moses as the first real commander; one of the greatest of all time and many are the merry quips sprung at his expense. Moses was a great commander. When he reached the Red Sea he lost confidence in his engineers and commanded the waters to part. His Field Orders No. 1, headed "General Headquarters, Sinai, 12 September, 1416 B. C., 10:00 A. M." in ten paragraphs is said to be the best form of an order ever published. His "thou shalt not's" carry the same force as if they were "thou shalt's" and there is no quibbling of words; no question of meaning. Now let us, for a moment, give way to fancy. Suppose we consider Moses, a man of prodigious energy and vitality, who has supervised personally all the details of the great march of the Israelites up to this time. One evening after a particularly hard day he feels his strength failing. He would like to reserve it for the more important duties of command. Thereupon he calls a trusted man aside. With apologies to our brother on a neighboring page of this magazine let us dispense with chronology and call this trusty Balam. "Balam" says Moses, "I feel a little tired tonight; I wish you would ride over to the left wing and see what its chances are of getting through that patch of wilderness tomorrow, and don't waste too much time in conversation with your mount." Balam returns with good information and advice which so pleases Moses that he says: "Balam, I am going to create a general staff; you are on the initial list." Now Balam soon finds his duties heavy so he calls unto him four men, addressing them thus: "Aaron, count the soldiers;" (G-1) "Jabez, look after the sheep and goats;" (G-4). "Simon, put over these hosts leaders skilled in the use of the spear and shield;" (G-3) and "Levi, trail thou along and let me know what old Pharoah is up to;" (G-2). Now Aaron, Jabez, Simon and Levi quarreled among themselves, whereupon Balam was sore put to and in the name of Moses sought peace. Thus Balam, without knowing it, became the first chief of staff.

Demarcation between command and staff is a sharp line in theory but apparently becomes a broad plane in practice. We have seen, either in maneuvers or in actual combat, staff officers supposed to be utterly devoid of the function of command ride out and tell a colonel to "take his regiment over to those woods" or to "halt here," etc. The colonel,

of course, understands that the staff officer is not commanding him but is merely delivering an order in the name of the brigade or division commander who, having made the decision to carry on a certain action relies upon his staff officers to execute the details and endows them with authority to do so. In the last analysis, the staff officer should explain to the colonel the full situation, telling him what is known of the enemy, how our own troops are disposed, what the commander has decided to do, what part he—the colonel—is to play, what the other regiments are to do and ending with common instructions applicable to the whole command. He should then follow up with the statement: "the commanding general has detailed me to transmit these instructions to you." The above procedure is, in fact, the gist of the formal field order. When written it may be signed by a staff officer "by order of the commander," or, when delivered verbally it may be transmitted by a staff officer in the name of the commander. To save time, in the stress of action the staff officer may deliver verbally only so much of the order as applies directly to the colonel in question and, in the grammatical second person, the matter takes on the semblance of a command. However, the colonel realizes that the staff officer has the whole situation in hand, that he is acting under direction of the commanding general and that the orders given have the force of a command as emanating from the commander himself. The commanding officer, after receiving all the reports and advices from his staff officers, makes the decision as to the action to be taken and assumes full responsibility for it. That is "command." The decision having been made the assistants carry out the details of the action. That is "staff."

Staff is indeed a wonderful institution. It conserves the energies of the commander and leaves his mind free to weigh the mighty issues leading up to the decision. Perhaps another great military leader who commanded the hosts of Moses some hundreds of years later had a subtle meaning when he loosed his lyre and sang "Thy rod and thy staff they comfort me."

Directors of National Rifle Association Elect Officers and Executive Committee

SENATOR FRANCIS E. WARREN, of Wyoming, was reelected President of the National Rifle Association of America at the annual meeting of Directors held in Washington, D. C., February 11, 1926. Other officers elected were: First Vice-President, Lt. Col. F. M. Waterbury, New York; Second Vice-President, Hon. Benedict Crowell, Ohio; Third Vice-President, Lt. Col. L. M. Rumsey, Missouri. Members elected to serve on the Executive Committee are: Maj. L. W. T. Waller, Pennsylvania; Maj. Francis W. Parker, Illinois; Maj. Gen. C. C. Williams, Chief of Ordnance, U. S. A., Washington, D. C.; Col. G. A. Fraser, North Dakota; Capt. G. L. Wotkyns, U. S. A., Springfield, Mass.; G. D. Pope, Michigan; Rear Adm. Montgomery Taylor, Chief of Fleet Training Section, Navy Department, Washington, D. C.; Lt. Comdr. E. E. Wilson, U. S. Navy, Washington, D. C.; Col. A. J. MacNab, Jr., U. S. A., Washington, D C.; Maj. Ralph Keyser, U. S. M. C., Washington, D. C.; and Brig. Gen. M. A. Reckord, Maryland National Guard.

Brig. Gen. Reckord was elected Executive Secretary of the Association, and C. B. Lister, Assistant Secretary.

The Directors of the National Rifle Association follow:

Terms end 1926: Maj. L. W. T. Waller, Jr., U. S. M. C. Res., Philadelphia, Pa.; Com. C. T. Osburn, U. S. N., U. S. S. Dallas; Capt. Karl D. Loos, Washington, D. C.; Lt. Col. David M. Flynn, N. J. N. G., Princeton, N. J.; Maj. Gen. F. C. Ainsworth, U. S. A., Ret., Washington, D. C.; Capt. G. L. Wotkyns, Ord. Dept., U. S. A., Springfield, Mass.; Maj. C. H. Wilson, Fla. N. G., Jacksonville, Fla.; Maj. Julian S. Hatcher, Ord. Dept., U. S. A., Frankford Arsenal, Philadelphia, Pa.; Maj. Fred M. West, Ore. N. G., Portland, Ore.; James E. Murray, Brooklyn, N. Y.; H. L. Day, Wallace, Idaho; Stuart Scott, New Rochelle, N. Y.; Maj. Harry L. Smith, U. S. M. C., Marine Barracks, Quantico, Va.; Col. E. C. Stodter, U. S. Cav., First Cavalry, Marfa, Tex.; Capt. Don A. Pruessner, Manchester, Iowa; Capt. Wallace Darling, Mass. N. G., Boston, Mass.; Capt. W. G. Layman, U. S. Inf., Ft. Benning, Ga.; Maj. J. K. Boles, F. A., U. S. A., Ft. D. A. Russell, Wyo.; J. K. Jensen, Albany, N. Y.; Maj. Harold Wirgman, U. S. M. C.

Terms end 1927: Lt. Col. Wm. H. Clopton, F. D., U. S. A., Washington, D. C.; Maj. Basil Middleton, Ind. N. G., Culver, Ind.; Maj. Francis W. Parker, Jr., Ord. Res., Chicago, Ill.; Maj. Nathaniel C. Nash, Mass. N. G., Boston, Mass.; Com. E. E. Wilson, U. S. N., Navy Department, Washington, D. C.; Maj. W. B. Randall, La. N. G., Shreveport, La.; Gustavus D. Pope, Detroit, Mich.; Gen. John R. McQuigg, Ohio N. G., Cleveland, O.; Com. W. A. Lee, U. S. N., Navy Yard, New York, N. Y.; Lt. Col. A. B. Critchfield, Ohio N. G., Shreve, O.; L. M. Rumsey, Jr., St. Louis, Mo.; Maj. Townsend Whelen, Ord. Dept., U. S. A., Washington, D. C.; Lt. Col. C. C. Stanchfield, Mass. N. G., Chelsea, Mass.; Karl T. Frederick, New York, N. Y.; Maj. J. B. Van Sciver, Del. N. G., Wilmington, Del.; Maj. Ralph Keyser, U. S. M. C., Hdqs. Marine Corps, Washington, D. C.; Brig. Gen. L. A. Toombs, La. N. G., New Orleans, La.; Maj. H. H. Kerr, Ohio N. G., Camp Perry, Port Clinton, O.; Lt. Col. Chas. W. Harris, Ariz. N. G., Phoenix, Ariz.; Brig. Gen. J. Clifford R. Foster, Fla. N. G.

Terms end 1928: Col. A. J. MacNab, U. S. Inf., Washington, D. C.; Col. Fred M. Waterbury, N. Y. N. G., New York, N. Y.; Russell Wiles, Chicago, Ill.; T. G. Samworth, Washington, D. C.; Capt. E. C. Crossman, West Los Angeles, Cal.; Brig. Gen. M. A. Reckord, Md. N. G., Baltimore, Md.; Col. G. A. Fraser, N. D. N. G., Bismarck, N. D.; Hon. F. E. Warren, Washington, D. C.; Brig. Gen. C. E. Black, Ill. N. G., Springfield, Ill.; Lt. Col. G. C. Shaw, U. S. Inf., Washington, D. C.; Col. George Kemp, Pa. N. G., Philadelphia, Pa.; Capt. Victor M. Hovis, Nebr. N. G., Lexington, Neb.; Brig. Gen. Bird W. Spencer, N. J. N. G., Passaic, N. J.; Maj. K. K. V. Casey, Wilmington, Del.; Maj. Gen. C. C. Williams, Ord. Dept., U. S. A., Washington, D C.; Dr. M. E. McManes, Piqua, O.; Hon. Benedict Crowell, Cleveland, O.; Capt. E. C. Austin, Colo. N. G., Denver, Colo.; Nod Cutting, Eagle Rock, Cal.; and R. V. Reynolds, Washington, D. C.

Personnel

Edited by Major John A. Brooks, Jr., Military Personnel Section, Office of the Chief of Ordnance

Maj. Gen. B. Frank Cheatham, Quartermaster General

EFFECTIVE January 18, 1926, Col. B. Frank Cheatham, Q. M. C., was appointed Quartermaster General of the Army with the rank of Major General, for a term of four years, vice Maj. Gen. William H. Hart, deceased.

Colonel Cheatham was born in Beech Grove, Tennessee, on May 20, 1867. He entered the Army during the Spanish-American War and served first as a major in the First Tennessee Infantry and later as major and colonel in the 37th Volunteer Infantry. During his volunteer service he took an active part in the suppression of the Philippine Insurrection. He entered the Regular Army as a captain in the Q. M. C. on Feb. 2, 1901, and has since that time rendered continuous service in the Q. M. C.

During the World War he served successively as Quartermaster of the First Division and as Quartermaster of the First Corps. He later served with the Quartermaster Corps at G. H. Q., as Quartermaster of the advanced Section, S. O. S., and as general inspector of the Q. M. C. On September 20, 1918, he was especially assigned as Commanding Officer of the 104th Infantry of the 26th Division, and commanded that regiment during the Meuse-Argonne offensive, and after the war, until the return of the Division to the United States. He was highly commended by both division commanders under whom he served.

Since the World War Colonel Cheatham has been graduated from both the General Staff School and the Army War College. He is at present on duty as Executive Officer in the Office of the Assistant Secretary of War.

Colonel Cheatham has been awarded the Distinguished Service Medal. His citation follows:

"B. Frank Cheatham, colonel, General Staff Corps (Quartermaster Corps) then colonel, Quartermaster Corps, United States Army. For exceptionally meritorious and distinguished services in positions of great responsibility. As Chief Quartermaster, 1st Army Corps, he displayed sound judgment, great initiative, and high professional attainments. Later, as colonel, 104th infantry, 26th Division, in operations against the enemy in the Meuse-Argonne offensive north of Verdun, October 14 to November 11, 1918, he rendered exceptionally valuable services, his high courage, leadership, and tactical skill proving important factors in the successful operations of the 26th Division during the second phase of the Meuse-Argonne offensive."

ARMY ORDNANCE extends to the new Quartermaster General its hearty congratulations and wishes for a most successful tenure of office.

Student Ordnance Officers at Army Industrial College

RECENT assignments among Ordnance Officers of the regular establishment include those of Majors C. T. Harris, Jr., James H. Burns, Bethel W. Simpson, Glenn P. Wilhelm, and Keith F. Adamson to the current class of the Army Industrial College, Washington. Majors Harris and Adamson are attending the College without relief from their assignments in the Ordnance Office, the former as Executive Assistant to the Chief of Ordnance, and the latter Chief of the Mobile and Seacoast Carriage Section, Artillery Division, Manufacturing Service. Major Wilhelm, who was formerly Chief of the Infantry and Aircraft Armament Division, has been succeeded by Maj. Wallace L. Clay, who has recently completed the course at the Industrial College, prior to which time he served on the staff of the Commander of the Hawaiian Department.

Major Simpson, who for the past four years has served as Chief of the Ammunition Division, Technical Staff, Office, Chief of Ordnance, has been succeeded by Maj. Thomas J. Smith, who also completed the last course at the Army Industrial College after serving as Commanding Officer at Benicia Arsenal, Cal. Lt. Col. Harry B. Jordan, who was a member of the last class at the Army Industrial College, has been assigned as a special student for the remainder of the present academic term at the Coast Artillery School, Fort Monroe, Va.

Capt. Carl C. Terry, also a graduate of the last class at the Industrial College, has been assigned to duty in the Office of the Assistant Secretary of War. 1st Lt. J. B. Bellinger is now assigned to the Recruiting Publicity Bureau with headquarters at Governors Island, New York City. Lieutenant Bellinger has already made quite a name for himself in the publicity field, his stories of the great open spaces having appeared in many of the popular fiction magazines. His assignment includes editorial work on the *Recruiting News* and augurs well for the continued success of that journal.

Reserve Officer Training, 1926

ARRANGEMENTS are being made for the training of Reserve Officers at Augusta, Frankford, Picatinny, Springfield, Watertown and Watervliet Arsenals from May 16th to 30th, inclusive, at Rock Island Arsenal from July 11th to July 25th, inclusive, and at Aberdeen Proving Ground from August 15th to 29th, inclusive. Funds are still available for training about 100 officers in the current fiscal year, and it is desired to utilize these funds to the best advantage by training all available officers

who, by reason of education, training or experience, are qualified to receive the maximum benefit from a period of training at one of the arsenals listed.

Preference will be given those officers who have not been heretofore trained, but who have sufficient experience or knowledge to receive the maximum benefit from the training given. Other conditions being equal, preference in this class will be given to officers who have been most active in furthering the interests of the Reserve or in better qualifying themselves for the duties to which assigned.

If funds remain this Spring after taking care of the officers referred to above, consideration will be given to training officers who completed the basic training course at Aberdeen or Rock Island in 1924. Officers will be trained at the nearest arsenal where appropriate training can be given. No officer will be recommended for training of a character which will not tend to make him of more value in his present assignment or if promoted. Requests for spring training should be submitted to the place to which assigned not later than March 1st.

Requests for Summer training should be submitted to the place to which assigned not later than May 1st. Later applications will be considered in the order in which received, but none will receive favorable action which reach the Office of the Chief of Ordnance less than 15 days before the beginning of the training period. In addition to the training scheduled above, a number of officers will be trained at their places of assignment at various times prior to June 30, 1926.

Washington Reserve Officers Honored

TWENTY-SIX Ordnance Reserve Officers were awarded certificates for faithful attendance at the course of lectures during the instruction year 1924-1925 at Reserve Officer Headquarters, Washington, D. C., in that city January 18, 1926. The occasion was the regular semi-monthly meeting of Ordnance Reserve Officers which for the past year has been held under the direction of Lt. Col. John Scott, Inf., who is in charge of the work.

Brig. Gen. John W. Joyes, Acting Chief of Ordnance, presented the certificates and congratulated the recipients on the year's work. Lt. Col. Isaac Weil, Ord. Res., Chairman of the Ordnance Section, Washington Reserve Officers, presided.

Those who received certificates, which were presented in the name of Maj. Gen. Douglas MacArthur, Commanding General, Third Corps Area, were: Lt. Col. Weil, Maj. Henry Erwin, Maj. David St. P. Gaillard, Maj. S. G. Green, Capt. P. B. Campbell, Capt. L. A. Codd, Capt. Leon Commerford, Capt. J. LeRoy Delany, Capt. Charles Demonet, Capt. J. C. Karnes, Capt. W. F. Mahony, Capt. A. T. Pagter, Capt. M. H. Resnicoff, Capt. C. G. Toepper, Capt. E. S. VanBrunt, Capt. W. F. Whittington, 1st Lt. W. L. Allison, 1st Lt. H. K. Cummings, 1st Lt. E. L. Davis, 1st Lt. L. W. Holland, 1st Lt. W. R. Lucas, 1st Lt. A. C. Oliphant, 1st Lt. A. E. Warren, 2nd Lt. E. M. Byrne, 2nd Lt. W. L. Christian, and 2nd Lt. J. A. Hickey.

Recently Assigned Ordnance Reserve Officers

THE following reserve officers have recently been assigned as indicated after their names:

Maj. Henry D. Ballou, Ord. Res., Manufacturing Service, Artillery Div., Washington, D. C.

Maj. French H. Morehead, Ord. Res., Manufacturing Service, Watertown Arsenal.

Maj. George L. Simpson, Ord. Res., Territorial Assignment Group.

Capt. Stephen T. Bandy, Ord. Res., Territorial Assignment Group.

Capt. Robert E. Johnston, Ord. Res., Territorial Assignment Group.

Capt. John T. Naylon, Ord. Res., Technical Staff, Aberdeen Proving Ground, Md.

Capt. Leon C. Stowell, Ord. Res., Manufacturing Service, New York Ordnance District.

Capt. Francis Xavier, Ord. Res., Territorial Assignment Group.

1st Lieut. Carl A. Bergmann, Ord. Res., Manufacturing Service, New York Ordnance District.

1st Lieut. Joseph P. Brady, Ord. Res., Manufacturing Service, Artillery Division, Washington, D. C.

1st Lieut. Stuart Naramore, Ord. Res., Manufacturing Service, Bridgeport Ordnance District.

1st Lieut. Norman E. Sill, Ord. Res., Manufacturing Service, Artillery Division, Washington, D. C.

1st Lieut. Max W. Winter, Ord. Res., Manufacturing Service, Tank, Tractor and Trailer Division, Washington, D. C.

2nd Lieut. Harry P. Bradley, Ord. Res., Manufacturing Service, U. S. Nitrate Plant, Muscle Shoals, Ala.

2nd Lieut. Kenneth N. Davis, Ord. Res., Manufacturing Service, Bridgeport Ordnance District.

2nd Lieut. John H. Doyle, Ord. Res., Territorial Assignment Group.

2nd Lieut. Fred N. Gregory, Ord. Res., Manufacturing Service, Chicago Ordnance District.

2nd Lieut. Warner W. Hall, Ord. Res., Manufacturing Service, Birmingham Ordnance District.

2nd Lieut. Clem W. Lepsch, Ord. Res., Manufacturing Service, Buffalo Ordnance District.

2nd Lieut. Charles H. Middleton, Ord. Res., Territorial Assignment Group.

2nd Lieut. John D. Nash, Ord. Res., Territorial Assignment Group.

2nd Lieut. John F. Nickell, Ord. Res., Territorial Assignment Group.

2nd Lieut. John J. Pentz, Territorial Assignment Group.

2nd Lieut. Bernard B. Stern, Ord. Res., Manufacturing Service, Cleveland Ordnance District.

2nd Lieut. Edgar C. Walthall, Ord. Res., Manufacturing Service, U. S. Nitrate Plant, Muscle Shoals, Ala.

Recently Appointed Ordnance Reserve Officers

THE following reserve officers have accepted appointment in the Ordnance Department Reserve:

Maj. French H. Morehead, Ord. Res., care Walworth Mfg. Co., Boston, Mass.

Maj. George L. Simpson, Ord. Res., 321 McKinley Ave., Eau Claire, Wisc.

Capt. Edward B. Anschutz, Ord. Res., 28 William St., Ansonia, Conn.

Capt. Arthur N. Armitage, Ord. Res., 550 E. 12th St., Pittsburg, Calif.

Capt. Stephen T. Bandy, Ord. Res., Ordnance Office, Camp Knox, Ky.

Capt. Robert E. Johnston, Ord. Res., Fort Mills, Corregidor, P. I.
Capt. Claude K. Shedd, Ord. Res., Rural Engr. Dept., Kansas State Agricultural College, Manhattan, Kans.
Capt. Leon C. Stowell, Ord. Res., Room 1513, 154 Nassau St., New York, N. Y.
Capt. Francis Xavier, Ord. Res., 3951 Kaimuki Ave., Honolulu, H. T.
1st Lieut. Joseph P. Brady, Ord. Res., 611 Otis Place, N. W., Washington, D. C.
1st Lieut. Stuart Naramore, Ord. Res., 312 Ridgefield Ave., Bridgeport, Conn.
2nd Lieut. Fred N. Gregory, Ord. Res., 610 LaFayette Ave. S. E., Grand Rapids, Mich.
2nd Lt. Thomas S. Hubbard, Ord. Res., 18 Sausse Ave., Troy, N. Y.
2nd Lt. William J. Lanier, Jr., Ord. Res., 5019 National Ave., West Allis, Wisc.
2nd Lt. Charles H. Middleton, Ord. Res., 2129 So. 65th St., Philadelphia, Pa.
2nd Lt. John F. Nickell, Ord. Res., 2316 Moffett St., Joplin, Mo.
2nd Lt. John J. Pentz, Ord. Res., 435 West Long Ave., DuBois, Pa.
2nd Lt. Edward J. Waterman, Ord. Res., 312 No. Oakland Ave., Green Bay, Wisc.
2nd Lt. Lysle A. Willits, Ord. Res., 504 16th St., Moline, Ill.

Reappointed Ordnance Reserve Officers

THE following officers have accepted reappointment in the Ordnance Department Reserve:

Maj. Charles H. Higgins, Ord. Res., 19 West 44th St., New York, N. Y.
Maj. Linn W. Searles, Ord. Res., 26 Drummond Ave., Chevy Chase, Md.
Capt. Edward H. Cahill, Ord. Res., The Engineer's Club, Philadelphia, Pa.
Capt. Charles D. Eskridge, Ord. Res., Fort Bragg, N. C.
Capt. Charles F. Risler, Ord. Res., care Wm. Risler, Bridgeport, N. J.
2nd Lt. Robert E. Andrews, Ord. Res., 704 Hinman Ave., Evanston, Ill.

Dr. Ernest J. Loring

ERNEST J. LORING, one of the foremost American authorities on the design and manufacture of bombs, died at his home in Washington, January 16, 1926.

Entering the Ordnance Department in January, 1918, as a Captain, Dr. Loring served in the Army until June, 1919, when he was honorably discharged. The first few months of his war service were with the Bureau of Mines, Worcester, Mass., where he was engaged on the design of Argon Gas Plant No. 3. From May of that year until his separation from the Service in 1919, he was stationed in the Bomb Design Section, Engineering Division, Office of the Chief of Ordnance, Washington, D. C., where he carried on important investigations of ballistics of bombs and development of bomb sights. Upon his resignation from the Army, Dr. Loring was engaged in civil pursuits until recalled to the Ordnance Department as an ordnance engineer in June, 1920, where his services were required in the further investigation of bomb ballistics.

For little more than a year he was stationed at Frankford Arsenal where he was in charge of experimental work on bomb sights. When responsibility for the development and test of bomb sights was transferred to the Air Service, Dr. Loring was permitted to complete certain designs on which he was at work. He was then assigned to the Office of the Chief of Ordnance to assist in the development of bombs and to further investigate their ballistics. He was engaged in this work at the time of his death.

Dr. Ernest J. Loring

Dr. Loring was one of the foremost ballisticians of the country. A pioneer in the field of bomb ballistics, he was successful in combining actual results with theoretical computations, and much of the present advanced state of bomb design in this country is due largely to his efforts. His remarkable achievements were due to a deep knowledge and application of higher mathematics, a sincere devotion to his work, and a loyalty which impressed all with whom he came in contact.

T. A. Gillespie

THOMAS ANDREW GILLESPIE, Chairman of the Board of the T. A. Gillespie Company, builders of the great loading plant at Morgan, N. J., during the World War, and a prominent member of the Army Ordnance Association, died at his home, Silver Spring, West Orange, N. J., January 27, 1926. Mr. Gillespie was seventy-three years of age.

The T. A. Gillespie Company was one of the largest manufacturers of munitions for the Allied Governments during the World War. During the first part of 1915 Mr. Gillespie was approached by agents for the Allies with a proposal that he build a plant for the manufacture of smokeless powder, of which, at that time, there was an acute shortage among the Allies. Securing the services of some of the foremost explosives experts in the country to

design and operate the plant, Mr. Gillespie, in a very short time, had in operation the Union Powder Works at Parlin, N. J., where were produced great quantities of the required explosives.

His success in this undertaking led to successful negotiations by the British Government for the erection of a plant and manufacture of 3-inch high explosive shells for use on the Russian front. Mr. Gillespie then effected the consolidation of several interests into the International Steel and Ordnance Corporation, which company manufactured, loaded, assembled and delivered 1,000,000 complete rounds of artillery ammunition for Allied use. These contracts were completed March 31, 1917, just a few days prior to the entry of the United States into the war.

The remarkable achievements in the construction and operation of the giant works at Morgan, together with the ill-fated explosion which practically demolished the entire plant, are well known to members of the Army Ordnance Association. Morgan was an excellent tribute to the ability and initiative of Mr. Gillespie and will always be remembered as one of the outstanding accomplishments in the production of munitions in this country.

A large part of Mr. Gillespie's life was spent in his native city, Pittsburgh, where he received his training in the manufacture and handling of large undertakings. For many years he was associated with the late George Westinghouse in the development of the natural gas industry of Pittsburgh. He joined the staff of the Westinghouse Company in 1884. Six years later, with his brother, R. G. Gillespie, he formed the contracting company of T. A. and R. G. Gillespie. In 1897 the T. A. Gillespie Company was incorporated, with headquarters in Pittsburgh and branches in New York and other large cities. It soon becamme one of the largest contracting concerns in the East.

In addition to the great Morgan projeet, the Company has to its credit the locks and dams for the United States Government on the upper Ohio River, the St. Lawrence Power Company's dam at Massena, N. Y., the plant of the East Jersey Water Company of Patterson, N. J., the Water Filtration Works and the third tracking of the elevated railroad lines in New York City.

Mr. Gillespie's clubs included the Union League, Lawyers' and Manufacturers' of New York, the Duquesne and Country of Pittsburgh, the Racquet of Philadelphia, and the Essex County Country Club of Orange, N. J.

His death marks the passing of a prominent member of the Army Ordnance Association whose record of service during the World War was preeminent.

Maj. C. O. Gunther, Ord. Res., Addresses Stevens Tech Students on Aberdeen Training Camps

"PROFESSOR C. O. GUNTHER appeared in a new role to the students at Stevens when as Major Gunther of the Ordnance Reserves, United States Army, and member of the Army Ordnance Association, he delivered a lecture upon "National Defense and the Ordnance Department," during the special lecture period of Wednesday, January 6th. He outlined the composition of our national defense, the make-up and duties of the Ordnance Department, and showed a series of slides and motion pictures of camp scenes and camp life at Aberdeen Proving Ground, Maryland.

"Our National Defense has three component units: The Regular Army, the National Guard and the Reserves. In case of emergency the first two are supposed to carry on until the organization of reserve forces is complete, a period of four months being alloted for the purpose. The Reserve Officers, who are men prominent in all possible walks of life, during peace times are engaged in organizing their respective industries so that in case of war complete co-operation with the government may be attained very quickly. The Ordnance Department, which must furnish all munitions besides most of the necessary accessory articles such as glass for range finders and periscopes, comprises in its reserve personnel many officers who have seen service, and also civilians who include scientists, engineers, college professors and graduates of colleges having R. O. T. C. courses. The camp at Aberdeen gives basic training in actual work to those students who take such a course. A six weeks stay at Aberdeen during at least one summer is required of each student before he can receive his second lieutenant's commission.

"Men at Aberdeen receive instruction in handling all kinds of guns, from pistols and rifles to the great 16-inch coast defense guns. Other instruction is received in driving tanks, and in gaging projectiles to fit accurately in gun barrels."—(*The State*—Stevens Institute of Technology, Jan. 13, 1926.)

Ordnance Orders and Assignments

CHANGES of assignments of Ordnance Officers of the regular establishment since the last issue of Army Ordnance, in addition to those noted on page 377, include:

Lt. Col. H. B. Jordan, Ord. Dept., U. S. A., to Coast Artillery School, Fort Monroe, Va.; Maj. R. L. Gaugler, Ord. Dept., U. S. A., to Organized Reserves, 3rd Corps Area, with station at Washington, D. C.; Maj. O. H. Presbrey, Ord. Dept., U. S. A., to Panama Canal Department; Maj. H. K. Rutherford, Ord. Dept., U. S. A., to Office Assistant Secretary of War, Washington, D. C.; Capt. W. T. Gordon, Ord. Dept., U. S. A., to Hawaii; and Capt. G. S. Lavin, Ord. Dept., U. S. A., to Delaware Ordnance Reserve Depot.

The following corrections apply to the list of stations and assignments of Ordnance Officers as published in the January-February issue of Army Ordnance: Lt. Earl Hendry, whose station was given as Raritan Arsenal, should read, "Ordnance School, Watertown Arsenal, Mass."; and Lt. T. K. Vincent, also given as Raritan Arsenal, should read, "Ordnance School, Watertown Arsenal, Mass."

Lehigh Ordnance Unit, R. O. T. C., Wins Laurels

THE newly formed Ordnance Unit, R. O. T. C., at Lehigh University has been gathering laurels on the rifle range. During the recent inter-mural match at the University teams of five men each were chosen to represent the four Infantry companies and the much smaller Ordnance Unit. The superior marksmanship and persistence of the Ordnance Unit enabled it to win the match with flying colors. Honors for the second highest individual score went to one of the members of the Ordnance Unit and two members of the Unit have since been chosen for the Lehigh R. O. T. C. Team.

Professional

Extracts from the Annual Report of the Chief, Bureau of Ordnance, Navy Department, for Fiscal Year, 1925

"IN CONSONANCE with the expressed policy of the Commander in Chief, this bureau will continue its effort to manufacture and supply to our fleet on the sea, beneath the sea, and in the air offensive and defensive arms intensely modern.

"It should be borne in mind that with the exception of the 3 *Marylands,* the 10 scout cruisers, and the 6 V's, that our fleet is not new and that there will be required new design and supply in order to keep it modern.

Inventive Genius

"Formally, in addition to the design force of the bureau, there were designers at the works of many private contractors, and the skill and ingenuity of these men were available in the current procurement of material. At present, due to the provisions of law, most of the material requirements of the Navy are met by Government establishments. This has caused the dispersion of the designing forces at the works of private contractors, and to a very great extent the naval service is forced to depend upon its own staff for new design. To counteract the tendency toward stagnation created by making the Navy dependent upon its own employees for new ideas, the bureau has endeavored to stimulate the inventive genius of its employees by using the provisions of the act of Congress approved July 1, 1918, which authorizes cash awards for useful inventions and ideas. The wisdom of this provision and the incentive offered can not be overestimated. During the year several valuable suggestions have been received from employees and cash awards have been made where it has been felt that they were justified. There is a prevailing idea that outside suggestions are not cordially received by the officers of the Federal Government; this impression is totally erroneous, and, speaking for the Bureau of Ordnance, I can say that every suggestion received is carefully investigated with a view to determining whether or not it will be useful to the naval service and whether or not the expenditure of public funds is justified to investigate the value of the suggestion. While it is true that only a very small percentage of the suggestions received are meritorious, nevertheless this bureau welcomes and seeks suggestions from persons both out of the service and in the service, and is constantly on the lookout for valuable ideas with the view to keeping the Navy modern.

Research and Development

"To the limit of available funds the bureau has proceeded with experimental, research, and development work. In addition, it has been found possible to interest a few private concerns in experimental work along certain lines. This work has been prosecuted diligently, and it is pleasing to note that some progress has been made and some developments have been brought to that point where it is possible to enter into production.

"Since we are building no new capital ships, because of our treaty, and no new destroyers, because of the large number already constructed, it is imperative that every effort be made to increase the effectiveness of the equipment of the ships that we have and to develop improvements for incorporation in any replacement ships that may be built. To realize the full value from this work it is necessary that a small and logical program of procurement be entered into so that new developments may be tried out under service conditions in the fleet where the personnel may learn the method of operation and develop the best means of utilizing the improved equipment.

"The main working appropriation of the bureau, 'Ordnance and ordnance stores,' for the fiscal year 1925 amounted to $9,025,000. This sum of money was just about sufficient, at a time when there were available some stocks of material which could be used without cost, to meet the upkeep and maintenance requirements of the fleet. In other words, with this appropriation the bureau, using stocks on hand, was just about able to provide necessary material for training, target practice, and maneuvers, and, in addition, to keep the material of the fleet in good condition. Nothing could be done toward providing new developments and new material, nor toward bringing up to date the equipment of the older ships which should be improved. Having presented this information to the Director of the Budget and to the Congress, the appropriation for 1926 is $10,375,250. This sum will enable the bureau to proceed in a small but orderly way toward the procurement of new material, toward the manufacture of new developments, and toward the improvement of a number of the vessels of the fleet in which improvements should be made in order that they may render the most efficient service. * * * *

Offensive Weapons For and Defensive Weapons Against Aircraft

"There has been much discussion during the past year as to the capabilities of aircraft and the ability to defend against them. Some proponents of a united air service have argued that aircraft and aircraft alone can provide an adequate national defense. These protagonists have minimized the offensive value of surface craft and their relative part in the general scheme of national defense,

and have belittled the powers of resistance of such vessels. At the same time they have endeavored to show the futility of any form of antiaircraft defense other than that by aircraft themselves.

"In the development and supply of offensive and defensive apparatus, not only for surface and subsurface craft but also for aircraft, these arms have been found to be so interrelated that the best results are only obtainable by close coordination and cooperation between the various types of naval craft. The bureau desires to voice here its expression of appreciation and thanks to the Bureau of Aeronautics for its increasing and untiring efforts to further the production and development of all apparatus, irrespective of whether it be for aircraft or against aircraft. It has been clearly determined that for the purpose of increasing the effective range and increasing the accuracy of fire of major caliber guns that the airplane is essential to combatant ships. Thus the airplane has become a part of the long-range fire-control system, and is as much so as the directorscope or the range finder and their personnel. As such, without considering their other uses, airplanes must be on ships of the fleet. This alone justifies and requires that the personnel and material belonging to such fleet aircraft should be in and of the Navy and not of a separate service.

"The development of weapons for the plane, such as bombs, fuzes, bomb sights, guns, torpedoes, etc., has proceeded regularly and progress has been made. Defensive weapons and apparatus have also been improved, and I am optimistic enough to hope and expect that notable advances will be made within the next few years.

"At the close of the World War the Navy was just being equipped with its first antiaircraft weapons. These being the first ever produced in this country and having been produced in the stress of war, naturally were susceptible to many improvements. However, this material was on hand. It was expensive and was capable of enduring many years, so, therefore, no changes of unproven value were recommended. Research, study, experimentation, and development were proceeded with, and until it was certain that material advances could be made no request for funds was made. The Director of the Budget and the last two Congresses have assisted the bureau, and soon it will be possible to install for trial afloat a limited amount of new, improved, and efficient apparatus. While the present antiaircraft guns are by no means modern, they are not negligible. The records of the Navy Department indicate that during the past year 16 battleships and 2 light cruisers held 42 practices against aircraft targets towed by airplanes. In 20 of these practices hits were made on the targets. While these practices were held under favorable conditions, nevertheless they represent the best reproduction of actual conditions that could be obtained. It is to be hoped that even this very creditable performance will be much improved by recent developments.

"With the development of automatic triangulation recording devices it will be possible to locate the point of burst of antiaircraft projectiles, thus enabling careful analyses to be made which will assist in gunnery training and technique. * * * *

Targets for Antiaircraft Guns

"One of the great difficulties encountered in antiaircraft gunnery and training has been the lack of a proper target. The towed target hitherto used has been too small to give a proper point of aim at high altitudes and too small to give a target large enough to register hits. Utilizing the Naval Aircraft Factory, the bureau has been developing a target of large size to be towed by heavier-than-air craft and a target of much greater size to be towed by lighter-than-air ships, singly or in tandem. If a number of targets can be towed by a lighter-than-air ship it will be practicable to simulate squadron attack and defense.

"The U. S. S. *Texas* and *Shenandoah* operated together during the week ending July 24, 1925. These operations were solely for the purpose of testing such targets, their towing gear and their handling. They were in no sense gunnery exercises, nor were they intended to be such. Although the *Texas* did fire a number of rounds with her antiaircraft guns at these new and larger targets with very good results, this was incidental to the test of the targets and target gear. From a material point of view the tests were satisfactory, and it appears that the expectations of the service for larger and better targets will be realized. * * * *

New Construction

"The manufacture of ordnance equipment for the airplane carriers *Lexington* and *Saratoga* has proceeded and the ordnance equipment will be delivered to meet the required dates of construction.

"The ordnance equipment for six 'V' submarines is being proceeded with. Deliveries will be made as required.

"Funds to the amount of $1,000,000 were appropriated at the last session of Congress for ordnance equipment of the two new light cruisers authorized. This sum will enable the bureau to get the pattern, foundry, and some machine-shop work under way in order that construction dates may be met. * * * *

Experimental Work

"To the limit of funds available, experimental and development work has been conducted actively. This work has been carried on principally through the agencies of stations under the Navy Department, such as the naval proving ground, Naval Gun Factory, naval powder factory, and Naval Research Laboratory.

"The bureau has maintained close liaison with other Government departments in order to prevent duplication and in order to profit by such tests as have been conducted by those departments. This is particularly so in case of the Chemical Warfare Service, Ordnance Department of the Army, Bureau of Mines, Bureau of Standards, and the National Research Council. * * * *

Naval Powder Factory

"During the past year the naval powder factory has produced 1,400,000 pounds of powder, 75 per cent of which was old powder reworked into new granulation and the remainder being new powder. The amount of new powder manufactured is just about sufficient to keep a

small nucleus of men engaged in its manufacture. It is realized that manufacturing such a small amount of powder is far from economical; however, the bureau considers that in the long run this manufacture represents an economy, as it keeps the powder factory in good condition, ready for use, and at the same time it permits the retention of a small body of trained men upon which expansion could be made in time of emergency. The amount of powder manufactured annually, namely, 1,400,000 pounds, is not quite sufficient to meet target practice requirements of the fleet each year, and by its manufacture no surplus is created.

"The railroad connecting the naval powder factory to the Pennsylvania Railroad at White Plains, Md., handled 894 cars during the year, of which 669 were for the Government and 225 for private parties.

"The chemical laboratory at the powder factory has made 1,373 complete analyses and 3,173 partial and separate analyses, and in addition has manufactured 130,000 sheets of violet paper for test of smokeless powder. * * * *

DECISION OF THE COMPTROLLER GENERAL

"Under date of May 28, 1925, the Comptroller General of the United States ruled that the appropriations of the Bureau of Ordnance are not available for the purchase of patents or patent rights. In this ruling it is stated:

"'In accordance with such unquestionable rule of statutory construction, it is only too apparent, as the appropriation 'Ordnance and ordnance stores' contains no provisions for such acquisition of a patent or patent rights for a general use, there is no authority to use that appropriation for such purpose.'

"For many years it has been the practice of this bureau to purchase patents and patent rights from its general appropriation, should such purchase be warranted by the usefulness of the patent or by its value for military purposes. In such purchases, which are very rare, the bureau has always purchased the patent or patent rights for the general use of the Government, although in many cases it was probable that such patents or patent rights were only usable by the Bureau of Ordnance.

"The changing of this policy of acquirement of the sole or limited use of the newest improvements in the equipment of vessels for the Navy appears to be detrimental to the national security and defense. Without the availability of some funds for this purpose the military advantages afforded by the sole ownership or control of essentially military designs or patents are lost to the Navy. The North Sea mine barrage could not have been laid without such availability, nor could secrecy in regard to many new developments be maintained. It is only in very rare instances that it would be desirable to acquire patents, it being preferable in most cases to make agreements of license. However, it does appear to this bureau that such right should exist and that the appropriations of the bureau should be available for such purpose, should, in the judgment of the chief of bureau, such acquisition be desirable for reasons of economy or secrecy.

"It is recommended that steps be taken to obtain a change in the wording of the appropriation act, in order that it may be possible to acquire patents or patent rights should they be required."

GAGES

New Limit-Gage Standard Makes Mass Production Possible to U. S. Industries

MASS production—that form of production which makes possible the largest output of the highest quality of goods at the lowest price and which was heretofore possible to only certain manufacturers—has been made available to all American manufacturers of machinery, vehicles, tools, electrical apparatus, and many other lines of products, through the standardization of limit gages which has just been completed and approved by the American Engineering Standards Committee.

Limit gages, upon which the new standard is based, are simple devices for checking dimensions with great accuracy. The preparation of the standard, which includes the method of using the gages and tables showing the degree of accuracy required in the inspection of parts for different classes of work, was the work of a committee of twenty-one experts under the chairmanship of Col. Eugene C. Peck, prominent manufacturer of Cleveland. The committee, which was under the official leadership of the American Society of Mechanical Engineers, was a very representative one. Not only the different industrial groups, but the Government, participated officially, the latter through the Army and Navy Departments and the Bureau of Standards.

When all American manufacturers use this standard gaging system, parts made by any manufacturer will fit corresponding parts made by any other manufacturer, thus making possible large scale production by any factory.

ECONOMY TAUGHT BY WAR

"The economy of interchangeable parts was a lesson taught by the War," said Dr. P. G. Agnew, Secretary of the American Engineering Standards Committee, in announcing the new standard. "It will probably be remembered that one of the triumphs of American manufacturing was the production of parts for machine guns and other arms, which were so completely uniform that perfect guns could be assembled from piles of thousands of parts mixed together without the necessity of any fitting work. This procedure at once established the production of arms on an enormous scale, and yet at a very low cost per gun.

"Exactly the same principle holds true with the manufacturing of other articles. For example, a wheel intended for a one-inch shaft made by one manufacturer should fit upon the one-inch shaft made by any other manufacturer. Under present conditions, however, this perfect fitting is rarely realized. The reason is that the wheel manufacturer bores the one-inch hole in accordance with one set of gages, while the manufacturer of the shaft uses a set of gages based on a different system. In consequence one piece may

be either a trifle too large or too small for the other, with the result that the wheel will either not go on the shaft at all, or else it will fit too loosely. If, however, both manufacturers had used nationally standardized, and therefore uniform, gages for determining the dimensions and had used these gages in precisely the same way, perfect fitting would be assured, no matter when and where the two parts had been manufactured.

Gages Assure Perfect Fitting

"Certain American manufacturers have been following well considered systems in their own works for many years and have been able to produce their parts in large quantity for use either for the assembling of new machines or for the repairing of old machines without further fitting. It was in order to unify these methods into a nationally uniform system and thus to extend the benefits to all American manufacturers who could use it, that the American Engineering Standards Committee undertook the work leading to this report on machine fits in interchangeable manufacturing.

"This report provides a classification of the various kinds of fits from the loosest as used in agricultural machinery and similar equipment, to the 'force or shrink fit' where, instead of fitting easily, the parts are pressed together under enormous pressure so as to be rigidly attached to each other and to stay there through severe use, as with a locomotive wheel and its tire.

"Much technical knowledge and experimentation were required to set up the table of fits. The clearance of play required between small parts, such as the shaft in a sewing machine and its bearing, is very different from that required for parts of a large rock crusher or a hoisting engine, and careful study was needed to work out a scheme of allowances that would cover the entire range. This, however, has been successfully accomplished by Colonel Peck's committee.

"In general, a certain fit between two mating parts will be obtained by checking the size of each part by means of two gages, each representing one of the two limits between which the actual size of the part must be kept. One gage is called the 'go gage,' the other one the 'not-go gage.' If only those parts are accepted which are shown by these two gages to be correctly machined, there will be positive assurance of perfect fitting.

Immense Savings Forecast

"It is to be hoped that all manufacturers engaged in making products with interchangeable parts will adopt the new standard so that uniform national practice based on the best of knowledge may be reached and maintained. This will result in enormous savings in labor and material, which will permit production of any given part on the largest possible scale, and will serve the customer directly by permitting quick and certain replacement of worn or broken parts.

"In fact, it has been estimated that the general use of this new 'key' to mass production will mean a saving of at least one billion dollars a year to American manufacturers.

"The question of fits and gaging has been approached from two different standpoints. The first is based on the immemorial custom of individual workmanship. The workman in fashioning by hand one part to fit another, endeavors to make it within a certain fraction of the required dimension with a permissible plus or minus variation. This idea, elaborated, leads to what is called the 'bi-lateral' system of gaging. The other approach is the more modern one through mass production and the repetitive process of automatic machinery. In this case the automatic machine is set to one limiting size and then is permitted to run, the tool wearing all the time, until the other limiting size is reached, after which the tool must be reset or replaced. Under these conditions, the permissible variation is thought of as being in one direction only and leads to what is called the 'uni-lateral' system.

"Within the last few years standards for gaging and for machine fits have been adopted in several important industrial countries, including Great Britain, Germany, Austria, Sweden and Switzerland. In each case there has been an extensive controvery as to which system, the 'uni-lateral' or the 'bi-lateral,' should be used. It is significant as indicating the trend toward mass production methods all over the world that the decision in every case has been for the 'uni-lateral' system.

"The plan for standardized 'Tolerances, Allowances and Gages' has been developed through the cooperative efforts of the constituent national technical, industrial and governmental bodies of the American Engineering Standards Committee. The Committee itself has therefore placed its final approval upon it and has presented it as a national standard to American industry."

EXPLOSIVES

Variations in the Color of Smokeless Powder Grains

ANTHROPOLOGISTS postulate the existence of two kinds of savages. Primitive savages, beginners in evolution as it were, with no great past record behind them. Then the rise of some kind of civilization and culture followed by a gradual decay with a reversion to type, resulting in what are called degenerate savages. A cycle of form has been completed.

In a somewhat analogous manner we may trace a cycle of color in the life history of smokeless powder grains, containing diphenylamine as a stabilizer. We start with primitive, cloudy, yellow grains, fresh grains from the cutter, which pass through a cycle of the spectrum colors until at the close of their life period they have degenerated to opaque, again yellow colored grains which are unstable and fit only for consumption in the fire "which maketh all things anew."

Cellulose used in the manufacture of celluloid is given a bleach treatment, so that films made from the nitrated material are almost colorless. But the cellulose used for smokeless powder is not so drastically bleached. As a consequence, a nitrocellulose solution or even a nitrocellulose gel turns a yellow brown upon exposure to air. This discoloration cannot be attributed to metallic iron or to iron oxide picked up in the preliminary treatment of the cellulose, for the amount of ash in smokeless powder grains is

so small as to preclude the possibility of the color being due to iron oxide. It is probably due to an oxidation of some kind. The color change is readily observed when a thin nitrocellulose solution, containing no diphenylamine, is allowed to evaporate spontaneously. The resulting film has a pronounced yellow or even brown color in marked contrast to the original solution. In fact it is not even necessary to evaporate the solution, for a colorless solution will develop a yellow color, simply on standing.

The change in color is also noticeable in reworked powder. That is, the scrap material from batches of powder, which accumulates and is stored in closed containers for perhaps twenty-four hours, is reworked into grains. This reworked material has a distinctly brown color as compared with the first run which has a yellow color. A part of the discoloration may be attributed to the oxidation of diphenylamine, but in any case, the new grains as they come from the cutter are more or less translucent with an amber yellow color.

Changes in color, perhaps already initiated, become more noticeable during the drying of the grains. They become more translucent but at the same time become a deeper brown in color. With continued drying they may become a deep brown, greenish brown, dark green, greenish black or black. At the same time there may be a loss in translucency so that the finished grain is opaque. Great variations are thus encountered in the condition of the finished grains from different lots of powder. They may vary from a translucent brown to an opaque black.

According to work done by the French, it is considered that the blackening of powders is probably due to the oxidation of diphenylamine to phenazine. At the same time, impurities in the diphenylamine may give rise to dark colored products which are related to phenazine. It is believed that the oxidation is caused by atmospheric oxygen dissolved by the alcohol or ether and particularly by bodies of the nature of peroxides which are present in "factory ether."

From work done at Picatinny Arsenal it has been found that fresh grains, containing one per cent of diphenylamine, when stored in a sealed glass container in daylight, turned black in a week's time at normal temperatures. This occurred in spite of the fact that the containers were completely filled with grains containing 45 to 50 per cent of solvent. The discoloration was not superficial but deep seated and it is rather difficult to see how a small amount of air in the presence of such a large amount of solvent could be entirely responsible for the oxidation in such a short period of time.

It has also been found that heat has an important effect in accelerating the blackening. New grains stored in sealed containers away from the light at 15 and 30 degrees, remained a clear brown for over a month. By heating at 45° they became an opaque brown in 5 days. A deep russet brown was achieved in 3 days at 60°, while blackening was produced in 8 hours at 75° or 3 hours at 90°. In addition the substitution of anhydrous ether (ether containing no peroxides) for factory ether, produced the same blackening in 3 hours at 90°; so that it seems probable that air entrained by the nitrocellulose plays some part in this oxidation reaction.

No blue grains have been observed at any time, but old black grains have been found which when dissolved in ether-alcohol, gave deep blue and indigo solutions; thus filling a gap in the color cycle. All the conditions necessary for the formation of "diphenylamine blue" are present in slightly decomposed grains. Sulphuric acid from the hydrolysis of cellulose sulphate esters, nitric acid from the nitrogen oxides liberated by the decomposition of the nitrocellulose and diphenylamine as a direct addition. So that it is not surprising that some decomposing grains should show colors in the range—blue, indigo and violet.

The interesting observation has been made that if thin sections are made of the black grains, sections thin enough for examination under the microscope, in all cases they have a pale yellow green color and apparent blackness in the whole grain is produced by the building up of layers of this yellow green material.

It may be assumed that a black colored compound, phenazine, is responsible for the color of the black grains, but a more satisfactory explanation for variations in color is that offered by the light diffraction theory. According to this idea, variously sized particles are formed by the oxidation of diphenylamine, a colloidal suspension in fact, and on account of the size and shape of these particles, light is absorbed and diffracted in different ways, giving rise to various colors. An analogous phenomenon is the fact that colloidal solutions of gold may be of a purple, red, yellow, brown, blue or violet color according to the size and shape of the particles in the solution. The fact that the color changes take place at normal temperatures and in an atmosphere of ether-alcohol apparently indicates that the discoloration is not simply and exclusively due to deep seated chemical changes, involving the formation of compounds with a definite color.

It is sometimes assumed that since the grain has turned black, diphenylamine has been used up and therefore less stabilizer is present. But a number of the oxidation and nitro derivatives of diphenylamine are almost as efficient stabilizers as diphenylamine itself. In addition the amount required to discolor the grain is exceedingly small. Large caliber grains usually have a dark color when their drying treatment is completed. This is due to the fact that an elevated temperature treatment is given them in order to reduce their content of volatile solvent to the proper figure. Many lots of large caliber grain have been found which, although having a black color after their drying treatment, showed no appreciable deterioration after a life of fifteen years. Blackening may occur therefore from heat treatment or from the formation of decomposition products, but it is not necessarily an indication that the grain has passed the zenith of its life cycle with consequent turning of its footsteps on to the broad path that leads to destruction.

Further decomposition of the powder results from the liberation of nitrogen oxides which are evolved by the spontaneous decomposition of the nitrocellulose. The nitrogen oxides combine with the diphenylamine with the formation of diphenylnitrosamine and other nitrated derivatives. Some of these compounds have been isolated from old powder grains and their occurrence is indicated by color changes in the grains themselves. These nitro deriva-

tives vary in color from orange red to red brown, to yellow brown, to lemon yellow. Their presence is indicated by spots or streaks on the grains. In some cases the Bolshevistic red nitrogen peroxide does its boring from within and grains have been found which were a glossy black on the surface but which were mealy and yellow inside. Other grains are exceedingly brittle and have a bright yellow color throughout. They are in an advanced stage of decomposition.

At this stage they are no longer pointed to with pride, but are rather viewed with alarm. They have completed a cycle from yellow to yellow, but the last state of these grains is much worse than the first. And so they are consigned to the tender mercies of Shiva, "Lord of the Burning Grounds."

A. J. Phillips,
Picatinny Arsenal.

ARTILLERY

Theory and Design of Recoil Systems and Gun Carriages

THE following memorandum of General Lefebvre, Inspector of Technical Research and Experiment of Artillery in France, to the Minister for War and Pensions, is a critique of the volume, "Theory and Design of Recoil Systems and Gun Carriages," published in 1923 by the Ordnance Department, U. S. Army (Document No. 2035). Coming from such a high source, it is felt that this opinion of a book, which has already attracted considerable attention, will be of interest to readers of Army Ordnance.

"General Lefebvre, Inspector of Technical Research and Experiment of the Artillery to the Minister for War and Pensions:

"With the above memorandum you sent me a volume published by the Ordnance Department, U. S. Army, entitled *Theory and Design of Recoil Systems and Gun Carriages,* instructing me at the same time to give briefly my opinion of this document, pointing out errors and omissions of the author, in case there were any, in order that you might comply with the wishes of the latter, as expressed to you through our military attachè at Washington. In my letter No. 907/A, of March 3, 1923, I stated that I was having the work in question translated and asked at the same time that the military attachè send me the special pamphlet relating to the application of the theory to the matériel in service.

"I am now able to send you the result of my examination of these documents and a statement of the principal observations to which it has given rise.

"This work, entitled *Theory and Design of Recoil Systems and Gun Carriages* is for the use of students in American Ordnance and Artillery Schools. In its present form it is the result of the collaboration of a number of officers or professors. The haste with which this edition was gotten out has prevented a thorough fusing of the various parts of the work and perfecting in detail. The result is a certain confusion in form which makes the reading of it difficult. For example, the last chapter entitled 'Miscellaneous' could be suppressed to advantage, the same ideas being expressed in other parts of the work, and a good deal of repetition would thus be avoided.

"It is necessary to point out also a lack of cohesion and frequent ambiguities in the notations, the same letter in the same chapter standing for different sizes, or the reverse. The unit pressures and total power resulting from them are constantly represented by the same letter. Frequently figures and text do not correspond (a figure on page 28 relates to a carriage the description of which begins on page 207). Finally, there are many mistakes in the figures (points of application and direction of forces, etc. . . . .) All these details are easily corrected, but it is true, nevertheless, that the accumulation of these mistakes, added to the frequent errors in printing, make the reading of the volume quite difficult. There would be no great advantage in sending a translation of this document, made in its present form, to the Artillery Schools of France.

"With these reservations, the work, which deviates considerably from French works of a similar character, presents a great many original and important developments.

"The determination of the strains made on the carriages in firing is quite thorough, as well as that of the resistance and dimensions to be given to the different parts. However, we must distrust the appearance of exactness of the formulas obtained, for they have been established as if the inner forces due to the elastic deformations of the material did not exist. However that may be, a study of this work can give useful points to builders in making their preliminary designs.

"The most important part of the work relates to the study of brakes and recuperators. It is difficult, however, to draw a general theory from it, for the problem of the construction of brakes is not stated there in all its breadth and complexity; there is treated rather a series of special cases, considered in succession without any apparent connection.

"We can, however, recognize therein a method of calculation for one brake. This method has the advantage of being easily accessible and not requiring anything more than elementary notions of mathematics.

"The author does not seek to establish the equations of motion in general; he takes the hypothesis of a constant total resistance to recoil or decreasing in proportion to the length of the recoil, and adopts, for the period during which the gases act, Leduc's empirical formulas of interior ballistics. It is possible then to readily determine the movement of recoil for each type of brake and recuperator. If the resistance varies according to a more complicated law, one returns to the preceding case, by considering small intervals and proceeding by successive approximations. The calculation of the brake orifices is made from time to time, as well as that of the return movement into battery.

"As the formulas arrived at frequently appear somewhat complicated, extensive use is made of empirical coefficients in order to simplify them.

"It is certainly easy to apply this method without extensive scientific knowledge. To the extent that we are able to compare these results with the reality, the calculations appear to be sufficiently accurate, within a hundredth. However, the data contained in the document do not permit us to make an affirmative statement in this regard, as it is

pointed out in the introduction that it has been necessary to make some changes in order to make the data agree with the numerical data of official documents.

"The disadvantage of this method is that, being founded on empiricism, it must constantly remain subject to verification in practice. But the author has tried to draw conclusions of a general character from formulas derived in this way which are paradoxical at least.

"The author is led to state that the length of recoil is independent of the ballistic conditions and of the inclination of the gun, but he has had to add in a note that this is not in accord with experience. It is equally true that this observation has led to his complete neglect of the study of the variations in the initial conditions of the fire and of viscosity in the operation of the brakes.

"Another paragraph stresses the importance of a strong constant resistance during the period of gas pressure. It seems on the contrary that the necessity of thoroughly insuring the stability of the brake at the beginning of the recoil, leads to the adoption of a constant value for the apertures of the brake over the length of this period.

"The theory of double recoil is presented in a clear and simple manner and the discussion on the best value of the compression ratio, taking into consideration the general conditions in constructing matériel (especially size and weight), seems original and comprehensive. The service of the gun is not discussed.

"To sum up, this work can be of service to technicians who are already familiar with the problem of the construction of mounts, but who dread employing higher mathematics. For the brake and recoil systems discussed, all of which are of French design save one which is of American design, it gives comparatively simple formulas and these are apparently sufficiently correct for preliminary designs.

"It is stated in the preface of the work that the present is not its final form; it will be followed by another edition which will take account of suggestions that may be made. The document would be of much greater service if the defects of form pointed out above were corrected. Only repeated use of the method would permit one to determine exactly its limitations."

An Arsenal of the Revolutionary War

Ruins of one of America's munitions plants during the Revolutionary War. Built in 1765 near Hellam, Pa., this furnace was used for casting cannon and cannon balls for the Continental Army. James Smith, a signer of the Declaration of Independence, was at one time owner of the furnace.

Patents

Brief Descriptions of Inventions of Interest to Ordnance Engineers

Compiled by W. N. Roach, Chief, Patent Section, Office of the Chief of Ordnance

SOME of the recently issued patents noteworthy to those interested in ammunition, are as follows:

William Dalton has secured patent No. 1,562,495, for an armor-piercing shell. This patent covers a specific form of base which is so weakened that it will strip from the shell upon striking armor plate at an angle without rupturing the inner walls of the explosive chamber.

Arthur Adelman, Office of the Chief of Ordnance, Washington, D. C., has been granted patent No. 1,563,418, for a fuze. This patent covers a percussion fuze in which a safety member is moved by centrifugal force to armed position, which member, during movement, moves the firing pin to armed position; the pin being then held in such position by air pressure.

Mr. Adelman has been granted patent No. 1,569,248 for a supersensitive fuze. This is a percussion fuze in which the firing pin is extruded by safety elements in moving to armed position; a slide which normally interrupts the powder train so formed that it may not rotate upon its longitudinal axis, and a special means for connecting the fuze elements, are provided.

Patent No. 1,567,232 has been granted to Harold M. Brayton, of Picatinny Arsenal, for a percussion element for time fuzes. In the design of this fuze there is provided a casing which may be attached to any standard time fuze in which casing is carried a percussion element acting, normally, as a safety, but armed during flight to permit functioning of the time element, or the percussion element upon impact.

Prof. Tenney L. Davis, of the Massachusetts Institute of Technology, who is engaged in special research work for the Ordnance Department, has been granted patent No. 1,568,502, for an explosive. This patent covers hexanitrocarbanilide as an explosive, or explosive mixtures or compounds containing such substance as an element.

Patent No. 1,569,545 has been granted to Oskar Junghans for a mechanical time fuze. The patent covers a special form of setting disk and special locking means therefor.

Artillery

Patents which have been issued on devices relating to Artillery are as follows:

Harry C. Zimmerman, of the Office of the Chief of Ordnance, Washington, D. C., has been granted patent No. 1,562,535, for a top carriage for guns. The top carriage covered by this patent is designed for light guns of the infantry accompanying type and the carriage is so formed that the trails may be quickly assembled thereon and the top carriage clamped to the carriage axle and the gun trunnions, one clamping means being provided for securing both clamps.

Mr. Zimmerman has been granted also patent No. 1,564,395, for a traveling lock for gun carriages. This lock consists of elements mounted on a carriage by a universal joint, the elements being adapted to be brought into engagement with the top carriage by means of cam levers.

Clarence H. Froelich has been granted patent No. 1,563,737, for a locking device for gun tubes. This device is intended to secure the gun tube in place with respect to the movable recoil element and consists of a shaft, the threads of which are adapted to engage complemental threads formed on the gun tube and the recoil element.

Patent No. 1,564,415 has been granted to Maj. Harry Hoisington, Ord. Res., of Rock Island Arsenal, for a fastening device for shields. The device covered by this patent is so designed that the shield will be firmly locked in either elevated or lowered position.

Maj. Oscar Krupp, Ord. Dept., U. S. A., has been granted patent No. 1,569,190, for a fire control apparatus. This patent covers a deflection board characterized by its simplicity of construction and operation.

Small Arms

Patents relating to Small Arms are the following:

Patent No. 1,563,052 has been granted to Heinrich Vollmer, for a cartridge feed mechanism. This patent covers a special drum-shaped magazine with a star wheel mounted at the orifice thereof to which wheel the cartridges are fed from the magazine by a spring pressed follower, the wheel acting to convey the cartridges through the orifice of the magazine to the automatic fire arm.

Josef Netsch has been granted patent No. 1,563,285, for a fire arm. This patent covers the special action of a bolt and accompanying parts through means of which action the gun may be fired automatically or as a single shot.

Herbert O. Russell and Chas. L. Paulus, of McCook Field, have been granted patent No. 1,563,438, for an operating trigger for double-gun mounts. This trigger is designed to be mounted on the trigger guard of one gun and to be manipulated to control the trigger action of the other gun.

Patent No. 1,563,675 has been granted to George H. Tansley for an automatic pistol. The object of this invention is to provide a small caliber practice pistol of substantially the weight and size of the standard Service pistol and to have the members so constructed that the pistol

will act automatically under the force of a small caliber charge.

John T. Kewish has been granted patent No. 1,563,751 for an automatic fire arm. This patent covers an arm having novel features designed to simplify construction and to improve the operation of the arm.

John D. Pedersen has been granted patent No. 1,564,014 for a fire arm. This patent relates to the firing pin and ejector construction of the arm.

Patent No. 1,565,443 has been granted to John W. Harkon for a front sight for high velocity weapons. This sight is designed to give windage allowance without lateral adjustment of either the rear or foresight.

Capt. W. T. Gorton, Ord. Dept., U. S. A., has been granted patent No. 1,565,560 for a hand trigger mechanism. This patent covers a mechanism designed to replace the trigger motor when hand operation is desired, the symmetrical design of the device permitting it to be mounted for right or left hand fire.

Hugh M. Rockwell has been granted patent No. 1,565,756 for an automatic gun. This patent covers a specific form of buffer intended primarily for use with the Browning gun.

C. G. Swebilius has been granted patent No. 1,565,826 for a fire arm. This patent discloses a sear mechanism so constructed as to permit either single or burst shots to be fired.

Thomas C. Johnson has been granted patent No. 1,566,877 for a bolt-action fire arm. This patent discloses a bolt retainer and cartridge ejector shaped and positioned to prevent accidental removal of the bolt.

Albin Gerstenberger has been granted patent No. 1,567,993 for a rifle with pistol breech mechanism. This rifle is so constructed that the complete pistol breech mechanism including the magazine may be removed from the rifle and a short barrel substituted for the rifle barrel so that the arm may be used as a pistol.

Chas. Sutter has been granted patent No. 1,568,005 for an accelerating device for automatic fire arms. The patentee has provided accelerating springs or the like which tend to hasten the return of the members to firing position.

William C. Speer has been granted patent No. 1,568,635 for a straight-pull bolt action rifle. The patentee has designed a bolt action intended to permit cartridges to be more rapidly ejected and injected into the cartridge chamber.

Patent No. 1,569,015 has been granted to Werner C. L. Haubroe for a machine gun support. The patent discloses a machine gun tripod provided with recoil springs so as to permit the gun to move rearwardly a short distance when fired.

Fred E. Lewis and Thomas J. Williams have been granted patent No. 1,569,553 for a safety attachment for firearms. This patent discloses a device adapted to be attached to the trigger of any firearm, the device being so constructed that the trigger cannot be accidentally released but may be manually released by the operator when shooting.

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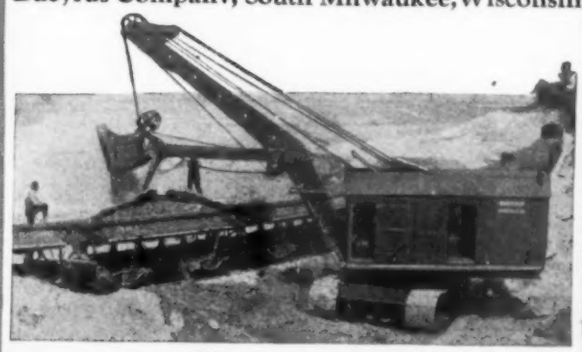

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Books

The Life of Elbert H. Gary: The Story of Steel. By Ida M. Tarbell. New York: D. Appleton & Co., 1925. $3.50.

SO many of the great men of our country's history rose from humble surroundings and so many excellent and inspiring biographies have been written about them, that the name of the subject is hardly so important as the name of the author, when one desires to purchase inspirational biography. In this book, however, both the subject and the author are nationally prominent, the former because he is the living barometer of steel, the latter because she wrote the indictment of the Standard Oil Company for the American public, and her powerful pen has held other corporations from evil practices. The public has confidence in her ability to find out the truth in Wall Street and to fearlessly publish it.

When Ida Tarbell takes up Judge Gary, we, therefore, expect a complete and honest revelation of his character, of his motives and of his accomplishments in his world of steel and finance, as well as, and incidentally thereto, his influence upon the politics of this country. We are not deceived. She has painted a true picture, with enough background and enough color to make its title and meaning clear and interesting. Judge Gary stands out as the lovable, optimistic, clear headed, highly experienced leader of men, whom the nation and the steel business have learned to admire and to heed.

There is nothing remarkable about the fact that Judge Gary grew up on an Illinois farm, that he followed the furrow, swung the cradle, pitched hay, milked cows, fed the pigs in the morning and evening and sang in the Methodist choir on Sundays. There is nothing new or startling in his study of law nor in his rise to the bench, nor in his practice of corporation law. In his practice in Chicago, he naturally came to the legal task of forming corporations of various independent units in the wire business, which led naturally to the steel business, for wire is made of steel and iron. His success in these fields indicated the possibilities of combining all elements of a line of manufacture from the original raw material to the finished product. He handled the legal side of such combinations until the gigantic corporation, U. S. Steel, was brought into being to cover nearly all types of fabrications of steel and iron things in the United States. This meant an unprecedented amount of the total wealth of the United States combined for a single purpose under a single directing head. This meant the erection of a single power that might rival the government itself or even dictate the national policies through its control of finance, materials and products. The Standard Oil Company had already attained similar proportions. Its ruthlessness in many places had frightened the people, had stirred the government, had aroused suspicion and hatred. It was an octopus to the cartoonists reaching with many tentacles into every one's business to stifle small interests or to take its toll by the right of might. U. S. Steel appeared as a new octopus with similar far-reaching arms to perpetuate the well known evil practices in the steel industry and to secure its profits by fair means or foul. It was of the greatest importance that someone who could inspire public confidence be chosen to control the gigantic enterprise and to prevent an attack by the public through the government during the infant days of the giant.

Mr. Morgan had wisely insisted upon Judge Gary as the chairman of the board of control and placed the determination of policies of the corporation in that board. In the scramble of finding who was really in authority in the new organization, Judge Gary had the support of Mr. Morgan and became the controlling personality. Mr. Schwab stepped out for other interests and the U. S. Steel came under the influence of a man of wonderful character and fairness, judicial poise, knowledge of and respect for law, a knowledge of men, a believer in the golden rule. Under his kindly and firm guidance, the steel corporation passed through a government investigation of the most searching character. Every facility was extended by Judge Gary for the judicial inquiry and the world was informed that the steel trust was a good trust. It was good because of Judge Gary.

His dominating influence in the steel industry was well understood by Ordnance officers during the World War. The effect of his word in his own organization and with all the independents, meant *so* much to Secretary Baker and to General Williams when steel appeared to be the choke point in ordnance production. His answer, "You will have it when and where you want it and at the price you find just," was carried out to the letter by the whole industry and might have been a determining factor had the war lasted.

He remains the dominating element in the world of steel, an influence for justice toward workmen, for fairness toward competitors, for square dealing with the public, for coöperation with his government, for good conduct of business leaders, both in commercial and private affairs. He is an optimist, a speaker of good tidings, having confidence in mankind and in the purposes and hopes of his country. He is earnest, continuously studying and learning. He keeps his finger on the pulse of the world. Out of his wide experience and his knowledge of present day conditions, he speaks with the tongue of a prophet and the world listens to him.

Miss Tarbell has made this all clear in her book. She writes pleasingly, searchingly, fearlessly, convincingly. She proves her case. Here, there is softness, kindliness, extenuation and compromise to contrast with the bitterness, the denunciation, and the demand for punishment of the

A Spider Web of Alloy Steel to Span the River and the Years

TOWNS are joined and become cities. Thousands speed back and forth, unconscious of the river they have to cross. Through heat and cold, rain and snow, the bridge supports its burden—making cities larger, homes nearer, waterways passable. And all because science has found a metal that will stand the stress of weights and loads—the pull of movement and vibration.

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The story of Judge Gary is truly the story of Christianity in business and it is the story of steel in the United States.

C. G. Mettler.

The Naval History of the World War (The Stress of Sea Power 1915-16). By Thomas G. Frothingham, Captain U. S. R. Boston: Harvard University Press. 1925. $3.75.

THIS, the second volume of Captain Frothingham's Naval History, deals with the two outstanding events, from a naval point of view, of the years 1915 and 1916—the abandonment of the Dardanelles adventure and the battle of Jutland. Much has been written, both in this country and in England, relative to the former and it will probably become the standard example of lack of the proper coordination between sister services, for ages to come. The author likens the Army and Navy during this attempt, to the two little human figures which alternate with one another in predicting "rain" and "clear" in a certain type of weather indicator. Only one comes to the front at a time. For, after the purely naval attempt to force the straits had failed, the Army landed and was finally left practically unsupported except for the Service of Supply. When evacuation of the Peninsula by the Army became inevitable, the Navy again had a plan for determined action! The only bright spot in the disaster was the skillful withdrawal of the Army without the casualties formerly considered inevitable in connection with these operations.

In a discussion of the effect of a *Mittel Europa*, the author minimizes the effect of a through railroad line from Berlin to Bagdad on British or other water borne trade, even under peace-time conditions. He quotes Mahan in support of the general proposition that in a conflict between land and water transport, the latter would probably win. This was undoubtedly Mahan's conviction, for he had expressed himself in a similar vein in several of his works, and it is the more remarkable in that he wrote at a time when the flourishing Mississippi River trade was disappearing and the elaborate canal systems of the United States were falling into disuse, due to the ascendency of the railroads. Our coastwise trade had also to be rescued from anhilation by legislative fiat. In 1890 Mahan admitted that the United States merchant service had disappeared and wrote "When for any reason sea trade is again found to pay, a large enough shipping interest will reappear to compel the revival of the War fleet." In 1907 he wrote "The open sea is a road which needs neither building nor repairs. Compared with its boundless expanse, two lines of rails afford small accommodations—a circumstance which narrowly limits their capacity for freight."

It is undoubtedly true that politics and financial considerations have served to becloud the issue as far as relates to our own country. Nevertheless, modern business has most often supported the rapid means of transport (the railroads) rather than the cheaper, slower means (shipping) where they have been in direct competition. In the face of this tendency, it would seem wiser to accept the conjectural ascendency of the water route to Bagdad as a possibility rather than a probability.

Captain Frothingham presents an extremely cogent account of the battle of Jutland, a vast improvement, in our opinion, on his monograph of 1920 on the same subject and perhaps as lucid and impartial an account as has thus far been published. An interesting side light is thrown on the status of the service of information of both Great Britain and Germany. Admiral Scheer apparently depended mainly on reconnaisance and when this service failed, as it frequently did, he was in the dark. A day or two before Admiral Scheer left port the British Admiralty received word of unusual activity in the High Seas Fleet and the departure of eight German submarines for the North Sea, which it promptly relayed to Admiral Jellicoe. The English were far ahead of their chief adversary in the use of the "directional wireless" by means of which the position of any sender could be ascertained.

The possessor of this means of detection had an enormous advantage, particularly when the enemy did not suspect its existence and inclined to the use of radio. The coast raiders and even the Zeppelins thus betrayed their whereabouts after elaborate preparations for secrecy had been made. But directional wireless at the time of the Battle of Jutland was not the accurate agency that it afterward became, for up till noon of that day the system reported the High Sea Fleet still in the Jade, whereas they had been under way since 2:30 A. M. After darkness had come on and Jellicoe was steaming south, the Admiralty reported the course of the German Fleet to within a quarter of a point and the correct speed, only 95 minutes after it had started its dash for Horn Reef. Neither this information nor the reports of cruiser contacts in his rear shook Jellicoe's determination to avoid a general night action, however. It is refreshing, too, to read a history of Jutland that does not use "low visibility" mistakenly for "poor visibility"—except once in a quotation from the English.

The author shows that the real reason for the falling off in intensity of the German submarine campaign on two occasions, was the tenor of the notes from the United States

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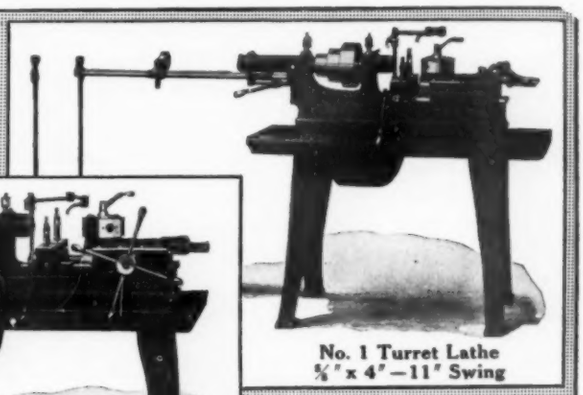

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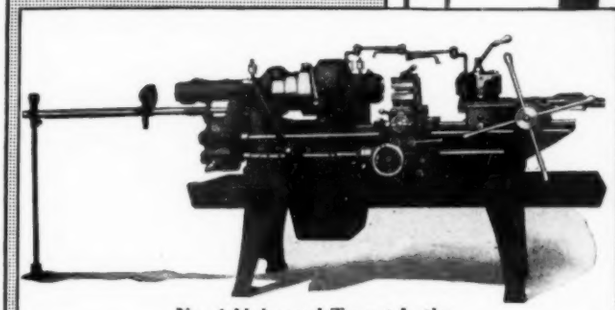

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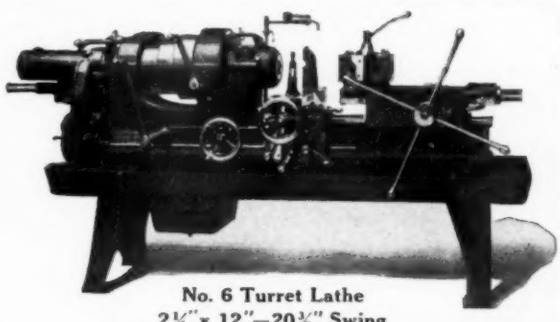

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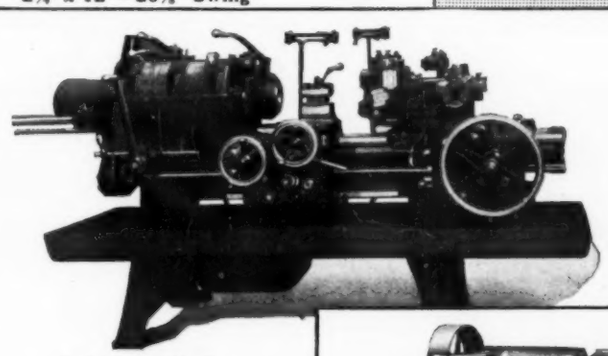

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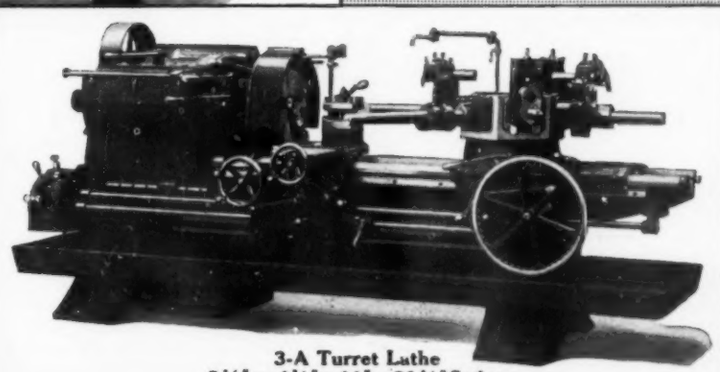

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and not the efficiency of decoy ships and patrols, as some enthusiasts at first thought. The supporters of the Zeppelin raids on London saw their awe-inspiring means of warfare fail in accomplishing anything decisive. The unrestricted submarine war finally decided upon, soon found its effective check in the convoy system. "This," concludes the author, "was to be another illustration of the old axiom that there will be found counters to all tactics and all weapons, and the effect of these counters must be considered in the result. This truth stands today as warning to those in the Services who may become prejudiced by the strength of their enthusiasm for some one means of waging war." A warning, aye, but not a deterrent to all.

The work is a readable, well arranged volume that bears the authoritative inscription "compiled from data provided by the Historical Section, United States Navy."

A. G. Zimermann.

Seven Wonderlands of the American West. By Thomas D. Murphy. Boston: L. C. Page & Company. 1925. $6.00.

IT IS difficult to say just who deserves the greater portion of praise for this volume, author or publisher. Certainly both have combined to produce one of the most interesting and most attractive volumes on description and travel that has been brought out in recent years. Mr. Murphy is not an unheralded writer of books of this kind, his "In Unfamiliar England," "On Sunset Highways," and "New England Highways and Byways" having already merited for him the distinction of being one of the best equipped travel authors. On the other hand, L. C. Page and Company have for many years been ranked in the vanguard of American publishers of quality. Both factors in the production of this book have done a remarkable piece of work.

In his description of the seven wonderlands, the author takes the reader through the Yellowstone, Yosemite, Grand Canyon, Glacier and Crater Lake National Parks, and the Zion Canyon and the Petrified Forests of Arizona. Those portions of the book relating to the Yellowstone, Yosemite and Grand Canyon, have already passed through five printings since first published under the title "Three Wonderlands of the American West." All of these sections, however, have been revised and added to in considerable detail. The book is embellished with thirty-two color reproductions from original paintings by Thomas Moran, N. A., and Professor H. H. Bagg.

Those of us who feel that we have, either through visit or book, become well acquainted with American nature grandeur will find a great deal in this volume of foremost interest. Even those of more prosaic mind to whom the admonition "see America first" has been more a catchword than a reality, will likewise find a most fascinating tour in store for them here. To go in to the descriptions of Mr. Murphy would be very much like the reviewer of plays who discloses the plot. As a matter of fact, the plot seems to be disclosed in the very title of this work. This, however, is deceptive for a typically American work. Clear in style, complete in detail, fascinating in subject matter, and pleasing in form, the "Seven Wonderlands of the American West" is preeminent in its field.

L. A. Codd.

Warfare: A Study of Military Methods from the Earliest Times. By Oliver Spaulding, Jr., Hoffman Nickerson and John W. Wright. Preface by Gen. Tasker H. Bliss. New York: Harcourt, Brace and Co. 1925. $5.00.

HERE is a book for the soldier. Begining at 3,000 years before Christ, tens of thousands of the soldiers of the King of Egypt—"each one carried as much with him as another; some of them stole the dough and the sandals from the traveler; some of them took the bread from each village; some of them took the goats from everybody." They went out to fight against the marauders from Syria. Those were great days for soldiers.

Somewhere around 480 B. C., the Persian soldiers, somewhere between 100,000 and 500,000 of them, went out to explore the world, especially to see Greece, which was said to be the finest place to live and the most beautiful to look at. They built a ponton bridge across the Dardanelles and found a small, but intrepid, band of Greek fighters at Thermopylae and a worthy band of sailors at Salamis. Many of them whitened the plains of Attica with their poor bones and others told great tales in Babylon of a wonderful journey. Tales of the Roman soldiers abound in this book; how they foraged, lived, fought, traveled all over the known world and came back to march in glorious array through the flower and flag bedecked streets of wonderful Rome in celebration of their victories; how they taught the barbarians to be real soldiers, to fight their battles for them and finally lose their own city to these children they had reared and trained. There is much, too, of the glorious days of chivalry when the soldier knights and soldier sergeants perspired and struggled over the ground like modern tanks, so heavy with armor that servants had to go with each one to place him on his horse or to lift him to his feet if he should fall. There are stories of the days

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of Cromwell, when the soldiers carried the hymn books on one side and the pike on the other, and sang the jubilant marching songs of Christendom as they drove through the ranks of the enemy.

Here is a book for the lieutenant and the company commander, telling how the ancients trained and disciplined the small units to hold together, to fight their little sectors of the grand battle with vigor, to accumulate and distribute supplies, to march into battle and to win.

Here is a book for the field officer, who was one time the independent leader of his own group of units, who was often, in historical times, chosen by his men to guide them, who had to accept later on a staff officer of the principal command to give him advice and direction, and who finally, for the sake of unity of command, lost his independence and became a direct appointment of the army commander. He has, nevertheless, kept his tactical leadership and his command is a tactical unit for battle direction.

Here is a book for the general officer, giving him a multitude of examples of success and failure and the causes therefor in all of the great battles which history records down to the end of the eighteenth century. There are so many examples of generalship taking the place of numbers of men; of generalship making up for deficiencies of equipment; of generalship counterbalancing distances from bases, lack of supplies, treachery and desertion, that one is tempted to rate personal ingenuity and bravery above many of the essentials of battle success.

Here is a book for the staff officer, who must handle the military intelligence, the plan of campaign, the position of battle, the route of march, the supply of munitions, the replacement of personnel, and the thousand and one details of the military movement in the home country or abroad.

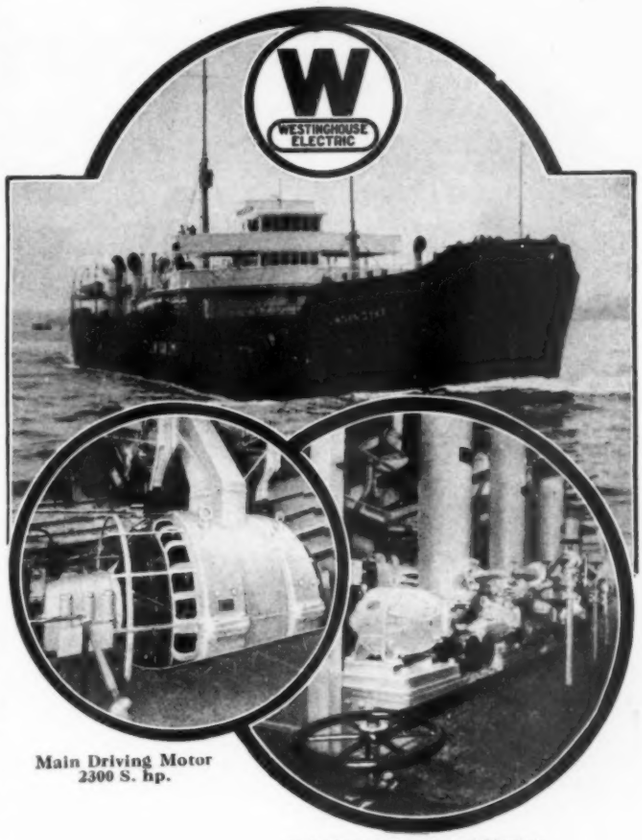
Here is a book for the student of history, who seeks the "whys" and the "wherefores" of actions of nations in working out their destinies.

And truly also, here is a book for the general reader, who desires to know by what strife and suffering and bloodshed, have been purchased the comforts of peace which he has come to enjoy, who desires to know how nations profited by the safety which military victories brought to their borders, and how he must act, not always as an independent, selfish unit among the people of the earth, but more often as a dependent and thoughtful member of a great nation in whose destiny he believes, even sometimes as its defender alongside his neighbors in battle array, giving the greatest gift he has to dispense, that the nation may continue its progress.

In these days of great haste and superficiality, one wonders that men should take the time to delve so critically and so deeply into all history; to extract from it so painstakingly and thoughtfully the trend of the methods of combat, and to expound this trend by so many examples set down chronologically through a long book. It is all there, from the first infantry marches on through the predominance of cavalry, its gradual disappearance and the great development of infantry warfare, the appearance of artillery and its waxing importance, the changes in tactics and strategy down through the days of Frederick, the Great.

As General Bliss says in his excellent preface to the book, the great machine for battle "differs from that employed by Caesar and Alexander only as the engines that drive a Leviathan or a Majestic across the ocean differ from that of the first steam propelled vessel."

C. G. METTLER.



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